AIR FORCE MATERIEL COMMAND (AFMC) MODELING, SIMULATION, AND ANALYSIS (MS&A) INTERACTIVE DATABASE

THESIS

Timothy J. Wagner, Captain, USAF

AFIT/GCA/LAS/95S-12

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GCA/LAS/95S-12

AIR FORCE MATERIEL COMMAND (AFMC) MODELING, SIMULATION, AND ANALYSIS (MS&A) INTERACTIVE DATABASE

THESIS

Timothy J. Wagner, Captain, USAF

AFIT/GCA/LAS/95S-12

AFIT/GCA/LAS/95S-12

AIR FORCE MATERIEL COMMAND (AFMC)

MODELING, SIMULATION, AND ANALYSIS (MS&A)

INTERACTIVE DATABASE

THESIS

Presented to the Faculty of the School of Logistics and

Acquisition Management

Air Education and Training Command

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Cost Analysis

Timothy J. Wagner, AAS, BS, MS

Captain, USAF

September 1995

Approved for public release; distribution unlimited

Acknowledgments

I dedicate this thesis to my beloved parents, Joe and Marietta Wagner, who believed in me and always encouraged me to try and do my best. I thank the Good Lord for helping me thorough what often seemed a never ending task. I am indebted to Lt Tim Ragsdale and Capt Kenn Scribner for our lively discussions and for their kind and gracious support. I wish to thank Lt Col Pepin and Maj Chimelski for their contributions, assistance, and support of this endeavor. I truly hope that this effort provides the foundation for the tool they were seeking. I want to express my deepest appreciation and thanks for the kind and understanding mentorship shown to me by Lt Col Chris Arnold and to Professor Art Munguia for his assistance and comments. Most of all, I wish to thank my loving wife, Janet, and my children who have forfeited much in order to make this, one of my dreams, a reality. Without their support, love, and understanding none of this would have been possible.

Timothy J. Wagner

Table of Contents

List of Figures

List of Tables

AFIT/GCA/LAS/95S-12

Abstract

This study develops a high level, unifying taxonomy for Modeling, Simulation, and Analysis (MS&A) products for the Air Force Materiel Command (AFMC). AFMC is concerned that limited resources are being expended on duplicative MS&A efforts. No mechanism exists that would confirm or deny this concern, so it was suggested that a database could be developed to catalog and track AFMC's MS&A inventory. First, it was necessary to determine the information that a decision maker needs to select a suitable MS&A product. Potential traits and characteristics were identified through review of current regulatory guidance, interviews with MS&A users, and a study of the current literature. Using the collected information, a survey was developed and distributed to 40 members of the Modeling and Simulation Technical Planning Integrated Product Team (M&S TPIPT). Survey results provided the foundation for developing a limited prototype database. This prototype was tested to ascertain the retrieval performance of the cataloging system. The test results failed to confirm the retrieval capability, but the test participants believed that cataloging AFMC's MS&A inventory would have great benefit.

AIR FORCE MATERIEL COMMAND (AFMC)

MODELING, SIMULATION, AND ANALYSIS (MS&A)

INTERACTIVE DATABASE

I. Background and Problem Statement

Chapter Overview

The use of Modeling, Simulation, and Analysis (MS&A) software, in support of Air Force activities at all levels, is becoming more prevalent every year. In response to this ever increasing use, a growing concern is that we ensure our MS&A resources are expended wisely. At the present time, there is no centralized inventory of MS&A software, which leads to difficulties in trying to control our MS&A expenditures. This chapter covers the general issues surrounding MS&A software, provides a concise statement of the problem, states the research question and objectives to be addressed, presents an encapsulated version of the research design, and describes the expected resultants of the research, namely a classification system and prototype database.

Problem Statement

The general issue facing the Air Force is the expenditure of approximately 60 to 70 million dollars each year on the development of MS&A software, according to Maj Steve Chimelski, HQ AFMC/XRX (3). A 1 Mar 1993 DoD Inspector General (IG) audit on

M&S found some related shortcomings that add to the justification of this research effort. The IG found that an "absence of a central library resource contributes to redundant investment; and FY93 DoD expenditures were estimated to be from \$1.3 to \$1.6 billion -- consolidation of effort could save an estimated \$800 million" (17: 1-2).

To understand the problem, a definition of terms is in order. Modeling is "a physical, mathematical or otherwise logical representation of a system entity, phenomenon or process" (22:7). Simulation is "a model implemented over time" and is "also a technique for testing, analysis, or training in which real-world systems are used or where real-world and conceptional systems are reproduced by a model" (22:7). Analysis is the use of models and databases to explore or define problem areas or potential difficulties that would be too costly, dangerous, or time consuming to accomplish by other methods. Thus MS&A is used for specialized applications such as reducing risk factors associated with new development efforts or modeling wartime scenarios which can not be done real-world at AFMC test, logistics, and product centers, laboratories, and headquarters.

At any one of these numerous locations, a developer creates or contracts for MS&A software to perform a specific task. However, the MS&A parameters or design may be identical to existing MS&A programs at another location. Currently, there is no centralized catalogue of MS&A products. Some centers have created an in-house catalogue, but there is no crossflow of information between centers, laboratories, or headquarters. Maj Chimelski estimates that the Air Force could save anywhere from 50 to 60 percent of annual MS&A software expenditures if such an integrated, user-friendly catalogue existed. Preliminary steps have been taken towards this goal; however, little has been accomplished by the HQ and the catalogue idea is in a state of limbo (3).

Research Problem Emphasis

The specific problem is to develop a classification system using identifying characteristics of MS&A products. A database could then be based on that system and used to facilitate the crossflow of information between MS&A user organizations. A database of such information would function as a repository of existing MS&A products that could be relevant to a particular problem or question. For example, a program manager for a new developmental fighter aircraft might be interested in any models that deal with aerodynamic simulations of supersonic aircraft. A user-friendly, interactive database would be the vehicle to provide the desired crossflow of information. At a minimum, the database should provide the title of the software, brief description, and a point of contact for further information. The database would also allow program managers in all parts of the country to cross-check any current MS&A software applications for use in their programs. This would save both time and funds by eliminating duplicate development efforts. HQ AFMC/XRX took the lead in attempting to develop such a database. They started with a massive data collection effort to capture the various types of MS&A software found across the Air Force. Unfortunately, the development effort has languished due to manpower and time constraints.

We must determine the characteristics and questions that must be addressed in order for a decision maker to decide whether to create a MS&A program or use an existing one. Some of the characteristics that may be critical to decision makers include the modeling technique employed in the program, the duration of the simulation run (run time), the user-friendliness of the program, or the learning that must take place in order to use the program.

The investigative questions which must be addressed are:

- What traits differentiate one MS&A program from another?
- Which traits are most useful to analysts in selecting MS&A software?

- Can a database based on a cataloging system which uses such traits provide acceptable retrieval performance for users?

Unless we are able to define a link between MS&A software and its application, the best we can hope for is a massive inventory list of every MS&A program in the Air Force. This list would have little practical application for program managers and would not answer the questions which led to this applied research project.

Research Design

My research method starts with surveying a panel of experts to obtain the important characteristics of MS&A software. The experts will be drawn from the individuals responsible for controlling and overseeing MS&A projects at Air Force Materiel Command labs, test centers, and product centers. Once the characteristics are defined, we will group the software according to those characteristics. We will also explore the thought processes involved in determining whether or not an existing software package would meet a program manager's needs or if it would be necessary to develop a new MS&A package. This information will provide the foundation for developing the database and canned inquiry transactions. Once the database structure is developed, it will be partially populated so that a field test can be conducted to evaluate the concept.

Expected Results

The end product of the research will be a classification system of MS&A software. A byproduct will be a prototype database system used to test the classification system.

The results of the test will provide an indication of the usefulness and applicability of the database. Once a database has been constructed and distributed to the field; it

should permit the Air Force to realize savings in the annual MS&A budget by reducing or eliminating unnecessary MS&A software development or purchases.

Summary

This chapter establishes the focus of this research effort. With an increasing use and dependence on MS&A software coupled with an ever decreasing budget, the Air Force must develop some method of matching current needs to capabilities. An effective database system of MS&A software as described in this chapter would provide the means for analysts to match their current simulation needs with existing MS&A capabilities. This thesis proposes a research objective and methodology which will address these needs.

II. Literature Review

Chapter Overview

Before pursuing the research objective of identifying MS&A traits and their differentiation usefulness, we should review the relevant information concerning MS&A, databases, and associated topics.

Information Systems

The general premise of this study is to provide program managers, analysts, and various other MS&A users a tool which can be used to provide an informational crossflow and to reduce the expenditure of funds due to redundant development efforts. The intent is for users to be able to query an information system to ascertain whether or not a MS&A tool already exists to answer their potential problem or question. An information system is defined as "a set of procedures that collect (or retrieve), process, store and disseminate information to support decision making and control" (10: 5). There are various types of information systems to support different levels of management as reflected in Figure 1.

Given the operational premise of this information system, we can conclude that we are basically dealing with a Transaction Processing System (TPS) because we are operating at an elementary level of querying data to answer a specific question. One way to approach implementing this TPS is by means of a database. A database is defined as "a computerized collection of stored operational data that serves the needs of multiple users within one or more organizations" (25: 4). Our needs fit neatly within the parameters of the above definition. We need a system that can function as a centralized resource of stored information that can answer queries concerning MS&A tools. This system must be able to provide this information to a wide range of users across AFMC at its many diverse locations. In order to answer these needs, we need to create an information system. This

system will most likely be in the form of a database, because this is the preferred method of delivery from the AFMC MS&A community's perspective (3).

	SALES	MANUFACTURING	ACCOUNTING	FINANCE	PERSONNEL
Executive Support Systems (ESS) Decision Support Systems (DSS)	5-Year Sales Trend Forecasting	5-Year Operating Plan	5-Year Budget Forecasting	Profit Planning	Manpower Planning
STRATEGIC-LEVEL SYSTEMS					
Management Info Systems (MIS) Office Automation Systems (OAS)	Sales Management Sales Region Analysis	Inventory Control Production Scheduling	Annual Budgeting Cost Analysis	Capital Investment Analysis Pricing/Profitability Analysis	Relocation Analysis Contract Cost Analysis
MANAGEMENT CONTROL-LEVEL SYSTEMS					
Transaction Processing Systems (TPS)	Order Tracking Order Processing	Machine Control Plant Scheduling Material Movement Control	Payroll Accounts Payable Accounts Receivable	Auditing Tax Reporting Cash management	Compensation Training & Development Employee Recordkeeping
OPERATIONAL-LEVEL SYSTEMS					

Figure 1. Hierarchy of Information Systems (10: 7, adapted).

Database Development

Database development follows a series of steps intended to provide a useful product that meets the using community's needs. The steps shown in Figure 2 and discussed below are a compilation of material from Teorey and Fry's text and class notes from an AFIT class, IMGT 699, Introduction to Database Systems taught by Lt Col Chris Arnold. Figure 2 shows the four database design steps in a graphical format.

Requirements Formulation and Analysis: We start requirements formulation by exploring the underlying purpose and reason for the database. We look at the body of data in question, the views and goals of the users, the support of senior management, and the organizational structure. This information is often collected through observation of the workplace and interviews with users and managers. Additional sources of information that should be reviewed are management reports, documentation, operating instructions, policy and guidance, and regulations that may impact the development effort.

After the interviews are conducted and the organizational documents have been reviewed, we concentrate on developing the data. A method for collecting the data must be formulated. Once specific information is identified as being required in the database, we are ready to proceed to the next step.

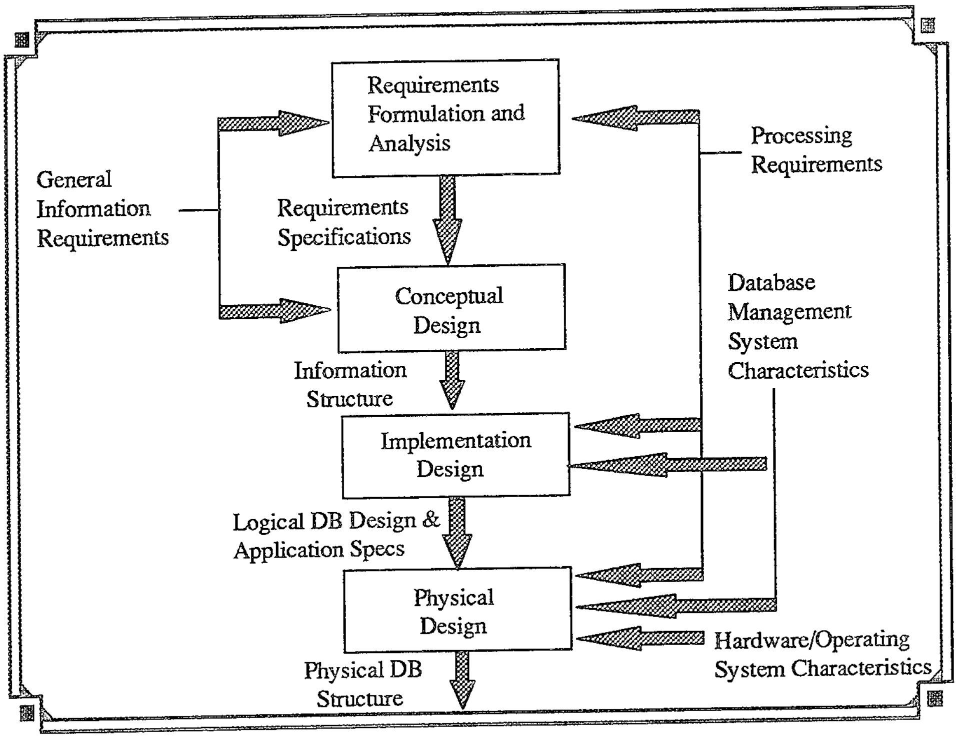


Figure 2. Basic Database Design Steps (25: 26, Adapted).

Conceptual Design: "The conceptual design concerns itself with the description and synthesis of diverse user's information requirements into a preliminary database design" (25: 27). The data collected in the first step of the design process provides the foundation for designing a high level conceptual representation or conceptual schema of the database. This representation is built by using an Entity-Relationship (ER) model. "The ER model describes the data as entities, relationships, and attributes" (6: 42). We map the physical world (i.e. the collected data) into a conceptual schema by using the ER model. Let's say we wish to model a college's student scheduling process. Information is

kept on every student consisting of name, social security account number (SSAN), resident address, permanent address, home phone, and academic program. The school has many departments with instructors assigned and courses for which the department is responsible. How would we depict this scheduling process in an ER-model? First, we need to identify the entities involved. An entity is "a 'thing' in the real world with an independent existence" (6: 43). Therefore, an entity could be a person, employee, school, house, department, course, or some other physical object. The describing characteristics of an object are called attributes. Thus, the attributes such as a person's name, SSAN, home address, and home phone could be used to describe an entity called student. After the entities have been identified and described (i.e. given attributes), then we need to look at how the entities interact among themselves. These interactions are referred to as relationships. Now that we have a basic understanding of the ER-model; we can proceed to develop the student scheduling process. Figure 3 shows what the student scheduling process would look like as an ER-model. The student entity has a relationship with the section entity. The student can enroll in many sections (thus an N on the section side) and each section can have many students (thus an M on the student side). The student also has a relationship with the department in the sense that a student can participate in only one degree program offered by a department (thus a 1 on the department side), but a degree program may have many students enrolled (thus an N on the student side). This is not to say that the department can not or does not have numerous degree programs, it merely means that each student can only be enrolled in one degree program at a time. Note the double lines between the student and department. This double line emphasizes that the relationship between the two entities is a "total participation" (6: 54). This means that every student is associated with a department and every department has students. Contrast this with the relationship between sections and courses. Each and every section offering relates to only one course. However, if a course is not offered that semester, the course will have no sections. Thus, each course could have one or more sections (so we

have the N on the sections side) yet each section is only related to one course (so we have a 1 on the course side). A course does not have to be offered each semester and, as a consequence, it would not have a section (thus a single line from the course side). This single line represents a "partial participation" (6: 54). Partial participation means that some part or subset of the courses entity is related to the sections entity for a particular term or semester. This example presents some of the considerations and conventions involved in constructing an ER-model. For the MS&A database, we will need to identify the appropriate entities with their associated attributes and the relationships between entities. Once this is completed, we are ready to design the database.

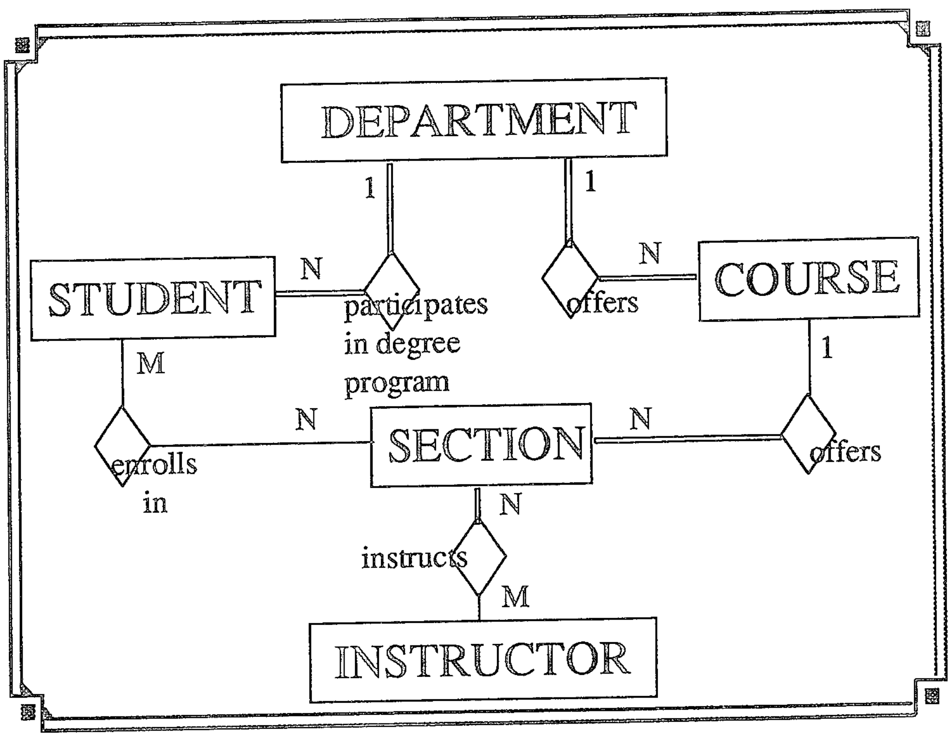


Figure 3. ER-Model Representation of a Student Scheduling Process.

Implementation Design: Using the results of the ER model, we define the relational model. "The relational model represents the database as a collection of relations" (6: 138). Relations may be thought of as tables. Each table contains rows of

data which represent a collection of related information or, from an ER-model viewpoint, each individual row would be an entity with its associated attributes. A physical example of a table would be the Dayton area phone book. Each individual listing of person or business, associated address, and corresponding telephone number would represent the information contained in an individual row and all of the rows, in total, would establish the table (i.e. the Dayton area phone book).

In a relational database, there are no explicit links between tables. Instead, a query language is used to make connections between tables. Consider the phone book example. Let that be one table and a second table consists of customers of a business. A row in the second table contains the name, phone number, and account balance for each customer. Now the address for each customer can be retrieved by matching customer phone numbers with the corresponding phone number in the phone book.

Once the relational model is developed, we can proceed to defining data dictionary. A data dictionary is defined as "a list of all database tables and fields" (26: 329). The database management system (DBMS) will automatically create this list which stores the name, lengths, type of data (i.e. text, number, date, etc.), and other information which provides an unifying, consistent format through out the database application. However, another function of the data dictionary is to resolve any ambiguities in what the data represents. For instance, if field is entitled WAGE, what value should be entered? Obviously one would enter a number value, but determining that number is where possible inconsistency could exist. The worker may very well view WAGE as the amount one brings home in a paycheck after taxes. Conversely, the IRS views WAGE as the amount paid to the employee before taxes. Finally the employer may view WAGE as the sum of pay, benefits, allowances, and contributions made on the behalf of the employee. Thus the field needs to be defined to help prevent any ambiguity and inconsistency. Once the relationships and data dictionary are defined, we can start building the physical database and inputting the data. From here we would progress to the last step of Figure 2.

Physical Design: The physical design covers three main categories: stored record format design, clustering analysis and design, and access path design (25: 28). Each of these looks at detailed, technical aspects of the database design such as partitioning of data items to different physical locations (i.e. a distributed database), memory allocation, central processor unit (CPU) speed and block size calculations for data retrieval, and other issues which are outside the design of this prototype database and this thesis. The prototype database is being used as a proof of concept of the MS&A traits and their usefulness; not as a completed, operational database.

Testing: The last step in the process would be a test of the prototype to gain an indication of how well the prototype performs. Although this is not a formalized step of the process according to Figure 2, it is nonetheless an important one. The review of the prototype by current simulation users will define the applicability of the MS&A traits.

Literature Sources of MS&A Traits

From an extensive review of the current literature, I was unable to find much concerning any taxonomies describing MS&A attributes in the commercial sector. T. I. Oren wrote an article addressing the attributes of cognizant simulation which is a specialized form of simulation that uses artificial intelligence (AI) developed from expert, rule-based, or knowledge-based applications. The taxonomy is split into two distinct segments: cognizant simulation and cognizant environments. The cognizant simulation is further delineated into six major categories which are "numerical simulation with nested neural nets, knowledge-based simulation, qualitative simulation, multiparadigm simulation, simulation with a nested knowledge-based system, and knowledge-based system with a nested simulation system" (15: 296). The cognizant environment is delineated into four categories which are "cognizant (intelligent) interfaces; cognizant environments for single paradigm and multiparadigm simulations (for models, model parameters, experiments,

programs, quality assurance, and for AI components); cognizant environments with a nested knowledge-based system; and comprehensive cognizant environments" (15: 302). Oren believes that his taxonomy is useful for several reasons because "one can perceive the unity of the field, one can classify the current achievements, and one can systematically explore promising new areas" (15: 293). The categories used in Oren's taxonomy lead to the potential idea of characterizing all simulation products based upon their code or internal structure.

Jenny Preece and H. Dieter Rombach have developed a taxonomy that provides "a framework to describe the approaches and techniques used in current software engineering (SE) and human-computer interaction (HCI) measurement" (18: 555). Often both of these areas strive to address similar areas of concern, however, they often do so with conflicting methodologies. For instance, a system may have had a streamlined and compact method for entering data (an SE approach), but, if the actual user finds the input method cumbersome or overly difficult, then the software has failed from an HCI perspective. The taxonomy they have developed attempts to unify the two disciplines by identifying common characteristics of any study. The taxonomy looks at four major dimensions of any SE or HCI study:

> (i) the goal of the study (what is being looked at and why?)
> (ii) the plan of the study (what is the underlying philosophy, how much and what kind of external influence is brought to the study and what is the location and design of the study?)
> (iii) the study methods employed (who does the study, what do they do and when do they do it?), and
> (iv) the kind of techniques that are used (how is data being collected, analyzed and validated, and how is the information derived from it being both communicated back to the project itself and reused to inform future projects?). (18: 556)

These major dimensions can be further refined as necessary to provide the required degree of detail about each study. Preece and Rombach believe that their taxonomy can

provide a unifying structure for these two diverse, yet intimately related, computer disciplines. The taxonomy establishes a common ground to provide the capability of reusing previously completed studies, planning for future research, guiding current studies, and facilitating communications between the two disciplines.

The last taxonomy to be covered is one developed by B. W. Hollocks. Hollocks reviewed the application of simulation in manufacturing within the United Kingdom (UK). The focus of this study was not on what simulation products UK manufacturing employs but in what areas of application the simulation was used to support. Hollocks identified 14 applications areas and queried simulation users as to the areas in which they currently use simulation tools. From the survey, it was found that:

> users employ simulation in on average 6 (5.98) of the areas. (The study found a minimum of two.) This is not surprising given the alliances between items in the list; for example, capital equipment decisions also commonly involve plant layout, line balancing is associated with manning levels, and material control rules affect inventory levels. (9: 107)

Based upon the results, Hollocks grouped the 14 application areas in five broad areas: facilities, productivity, resourcing, training, and operations. Hollocks' study points out that even if a taxonomy can be established, it may not have a high degree of resolution because the simulation can be so intertwined in their application areas.

Even given the few examples above, I was unable to find any taxonomy which attempted to draw together, into one unifying framework, all of the different aspects of M&S. This, in itself, is not surprising. Many well known simulation packages are generic in nature; designed to address many potential problems with a formalized approach. Examples of some of the best known simulation software languages are SLAM, GASP, SIMAN, and SIMSCRIPT. Conversely, Air Force simulation packages are often designed to address a specific problem or application. Many of the different sources used to identify varying characteristics of MS&A are discussed below.

DoD 5000.59-Paa, Modeling and Simulation (M&S) Master Plan (Draft).

The primary source describing the current state of military MS&A guidance is DoD 5000.59-Paa, Modeling and Simulation (M&S) Master Plan (Draft), January 1995 prepared by the Under Secretary of Defense (Acquisition and Technology). The plan is the definitive source for policy and guidance within the DoD for M&S and it "implements policy in DoD Directive 5000.59; establishes DoD-wide M&S objectives; provides a comprehensive framework for the planning, programming, and budgeting of M&S projects, programs, and activities; and assigns responsibilities for its implementations" (27: i). To oversee these activities the DoD Executive Council for Modeling and Simulation (EXCIMS) was established. The EXCIMS formulated a direction and vision for M&S:

> Defense modeling and simulation will provide readily available, operationally valid environments for use by DoD Components:
> - to train jointly, develop doctrine and tactics, formulate operational plans, and assess warfighting situations
> - to support technology assessment, system upgrade, prototype and full-scale development, and force structuring
>
> Furthermore, common use of these environments will promote a closer interaction between the operations and acquisition communities in carrying out their respective responsibilities. To allow maximum utility and flexibility, these modeling and simulation environments will be constructed from affordable, reusable components interoperating through an open systems architecture. (27: 2-1)

A visual representation of the EXCIMS vision is reflected in Figure 4. The EXCIMS vision offers an unifying concept which ties together the varying levels of M&S, the different areas of application, the broad range of user organizations, and the many perspectives and requirements of M&S. This leads to the idea that M&S can be characterized by these unifying concepts. For instance, the scope of M&S can be represented from the lowest level of subsystem/component tools to the high level theater/campaign models. More will be discussed about the hierarchy (scope) of M&S

models in the Systems Acquisition Manager's Guide section below. The functional area of application suggests that M&S could be defined by the functional orientation of the model. Models could be categorized as being most applicable in the following areas: Education, Training, and Military Operations; Analysis; Research and Development; Test and Evaluation; and Production and Logistics. The list of additional M&S dimensions in Figure 4 suggests that these concerns might prove useful in describing various capabilities, traits, and characteristics of MS&A.

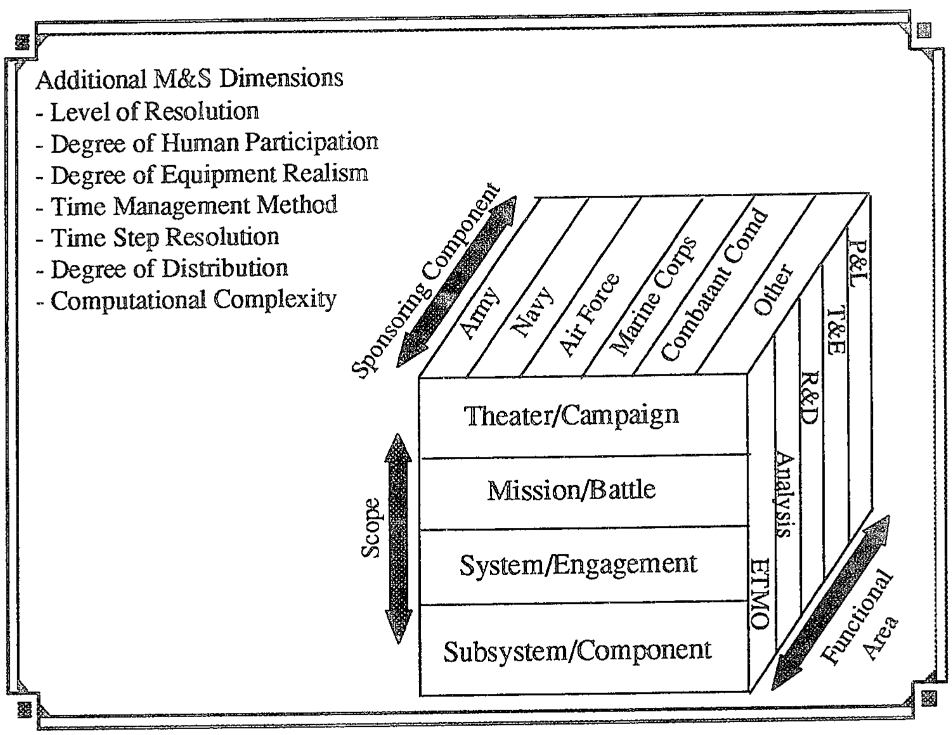


Figure 4. Range of M&S Embraced by the EXCIMS' Vision (27: 2-3).

Figure 5 is a depiction of the four pillars of military capability which are readiness, modernization, force structure, and sustainability. The first pillar, Readiness, is enhanced by "allowing Combatant Commands and Services to train forces, develop doctrine and tactics, assess performance of units, evaluate operational plans, conduct "what if" analysis

on those plans, and rehearse missions" (27: 2-4). Simulation allows training to be conducted on a joint level without physically moving forces by means of an interactive, synthetic battlefield. Computer generated forces can interact with human participants under actual field conditions using operational weapon and command and control systems. Feedback, both real-time and after action reports, can be used to refine operational plans, doctrines, and tactics, to assess operational deficiencies or to define unit effectiveness and readiness.

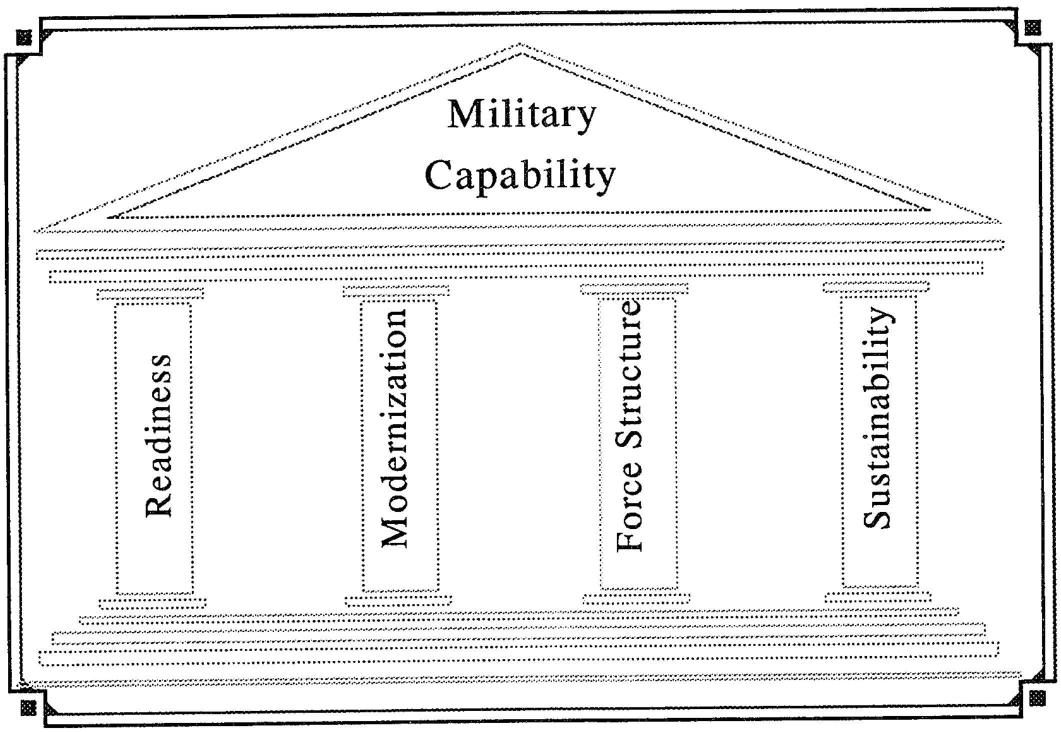


Figure 5. Four Pillars of Military Capability.

Modernization, the second pillar, can benefit from M&S by reducing "the time, resources, and risks of the acquisition process" and to "increase the quality of the systems being acquired" (27: 2-5). Proposed weapon systems can be tested for their impact upon operational and logistics systems. M&S can provide preliminary test results of a weapon

system under varying environments and conditions to help ensure that a realistic test and evaluation scenario is being followed.

The next pillar, Force Structure, will benefit from M&S by giving "DoD leadership a powerful arsenal of tools to analyze alternative DoD force structures" (27: 2-7). Senior DoD leadership can evaluate the response to and capabilities of changes made to the force structure under conditions that can not be tested in a real world scenario or within a timely fashion.

Sustainability, the last pillar, can be improved by integrating "combat models to allow for the analysis of combat sustainability; to study the effects of organization size, basing, and doctrine on the logistics infrastructure; and to determine the implications of alternative material management, maintenance, and resourcing policies" (27: 2-8). With the tremendous impact of simulation in each of the four pillars of military capability, it seems reasonable that this could provide another potential identifying trait for MS&A.

Systems Acquisition Manager's Guide

One of the most helpful sources describing MS&A applications in the DoD today is the Systems Acquisition Manager's Guide for the Use of Models and Simulation developed by Colonel Lalit K Piplani, Lt Colonel Joseph G. Mercer, and Lt Colonel Richard O. Roop. Military simulation applications span a wide range of problems. The Air Force uses a hierarchical system to describe the various applications of MS&A packages. Figure 6 shows the hierarchy consisting of five levels: Strategic/National Military Strategy, Theater/Campaign, Mission, Engagement/Submission, and System/Subsystem Component (17: 3-16 and 3-17).

The Strategic/National Military Strategy simulation packages model the highest level of political, economic, and military policies and concerns. Policy decisions such as force structure for a two-front war, impact of the drawdown, forward basing considerations, availability and distribution of allied forces, and collective security

agreements or alliances would be addressed at this level. The results of this level of simulation are strategic in nature and represent a duration of weeks, months, or years.

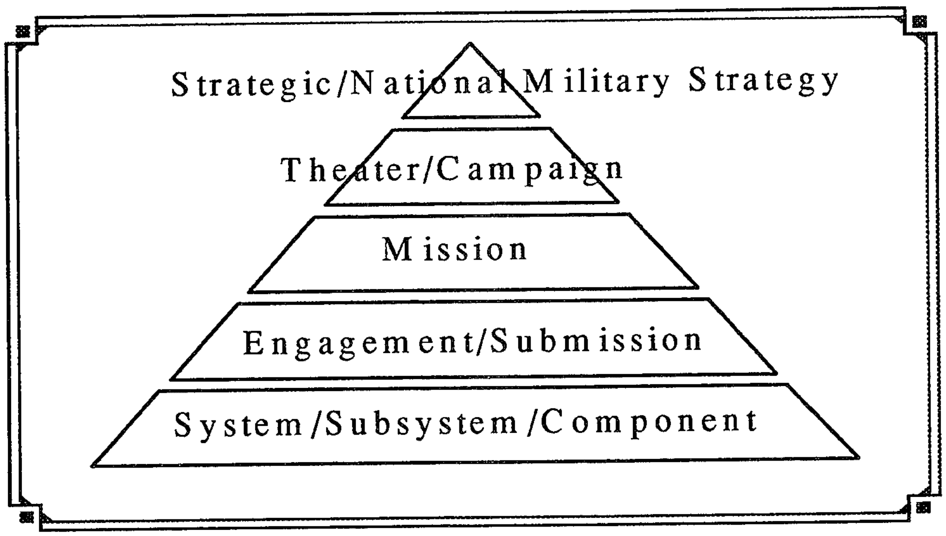


Figure 6. Air Force MS&A Hierarchy.

The Theater/Campaign level models a wartime scenario addressing various aspects of aerospace power within theater(s) of operations. The defense of Europe or the repelling of a North Korean attack would be modeled at this level. Casualty rates, spares usage, resupply needs, mission effectiveness, and other like concerns would be addressed. The results of this level of simulation are strategic and operational in nature and represent a duration of days to weeks.

The Mission level models various aspects of aerospace power as it relates to a particular mission. A bombing run on a heavily defended airfield could be analyzed to determine casualties, best avenue of approach, best mix of aircraft and capabilities, and probability of success could be evaluated. The results of this level of simulation are operational and tactical in nature and represent a duration of hours.

The Engagement/Submission level models a specific or finite set of assumptions or criteria to determine performance. How a flight of fighter/bombers fares against a battery

of surface-to-air missiles could provide valuable input to the Mission level analysis concerning the potential risks of attacking a heavily defended airfield. The results of this level of simulation are tactical in nature and represent a duration of seconds to minutes.

The System/Subsystem/Component models a wide range of scientific, engineering, and management related questions concerning specific systems, subsystems, and components operating in various operating environments. An engineer might be interested in how much stress to which a landing gear is subjected, a scientist might be interested in the results of new chemical bonding process, and a manager might be interested in the cost for a new communications system. The results of this level of simulation could be considered tactical in some applications and represent a duration from micro-seconds to hours or more. The comparison in Figure 7 shows that the Army uses a hierarchy similar to the Air Force with the exception of not having a Strategic/National Military Strategy level (17: 4-6).

As shown in Figure 7, the lowest level of the Army hierarchy is the Engineering level used for design, cost, manufacturing, and supportability studies which would be comparable to the Air Force's System/Subsystem/Component level. The next level of the Army hierarchy is the Engagement level used for evaluating system effectiveness against enemy systems which would be comparable to the Air Force's Engagement/Submission level. The next higher level of the Army hierarchy is the Mission/Battle level used for evaluating the effectiveness of a force package which would be comparable to the Air Force's Mission level. The highest Army level is the Theater/Campaign level used for determining the outcome of joint or combined forces in a theater/campaign conflict which would be comparable with the Air Force's Theater/Campaign level.

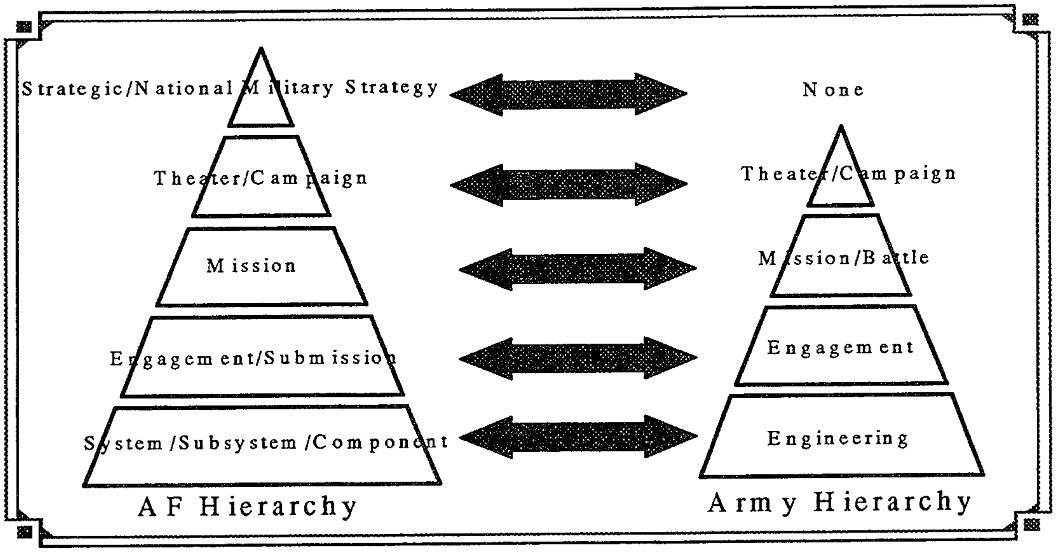


Figure 7. Comparison of AF versus Army Hierarchy.

The guide views the user community as being divided into the following functional areas: research and development: test and evaluation; analysis and production and logistics. Education, training and operations concentrates on the re-creation of historical battles, doctrine and tactics development, command and unit training, operational planning and rehearsal, and wartime situation assessment. Research and development is concerned with requirements definition, engineering design support and systems performance assessment. Test and evaluation focuses on early operational assessment, development and operational test design; and operational excursions and post-test analysis. Analysis is concerned with campaign analysis, force structure assessment, system configuration determination, sensitivity analysis and cost analysis. Production and logistics covers system producibility assessment, industrial base appraisal and logistics requirements determination (17: 2-2).

The guide suggests that there are three general types of models: wargaming; training; and acquisition. "Wargaming models range from single engagement (one-on-one) to joint theater level campaign operations. Training models range from single template instructional systems to complex virtual reality simulations. Acquisition models

range from physical level phenomenon models through engineering component design tools to models of systems-in-the-end-use-environment" (17: 1-3).

Another potential trait is describing MS&A in terms of defense systems acquisition programs. The guide includes a figure, reproduced below as Figure 8, which shows the interrelationship between the three decision-making support systems. The three systems are requirements generation, acquisition management and the planning, programming and budgeting system (PPBS) (17: 2-3).

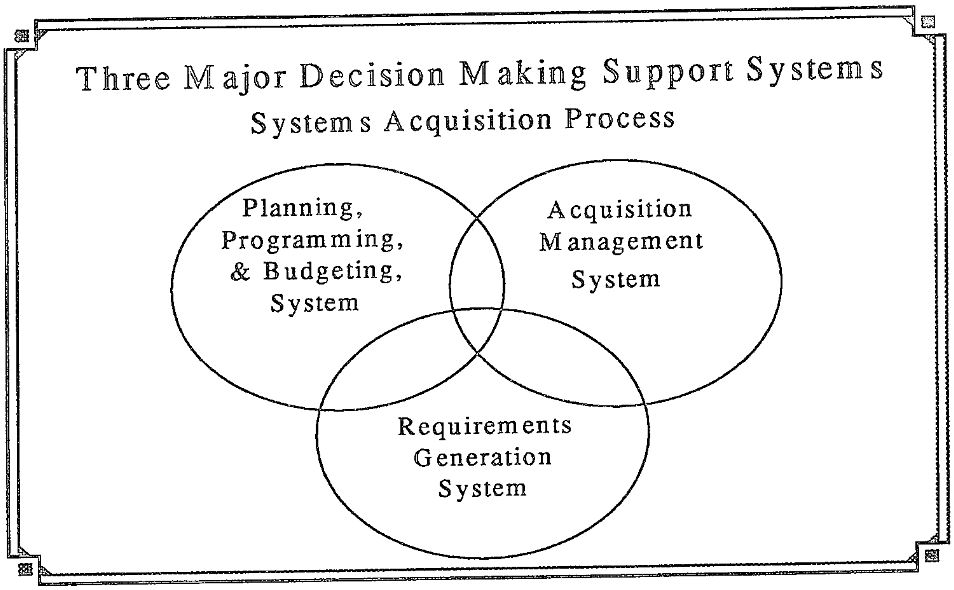


Figure 8. Three Major Decision Making Support Systems (17: 2-3).

The Systems Acquisition Manager's Guide provides an excellent tool for educating program managers on the role and application of modeling and simulation in the realm of system acquisition.

Law and Kelton's Simulation Modeling and Analysis

In addition to using both the DoD Master Plan and the Systems Acquisition Manager's Guide, Law and Kelton's text is valuable. It discusses the fundamentals of modeling and simulation design. This leads to the idea that some of the potential traits

could be tool specific. For instance, a model that represents a system at a particular point in time is referred to as static (11: 3). Conversely, models that represent a system as it evolves over time are referred to as dynamic. For those models that are dynamic, how it represents a system could be distinguishing trait. If the dynamic model evolves over time and the state variables only change at a countable number of points in time, then the model is considered discrete (11: 3). However, should the state variables change continuously over time, then the dynamic model is considered to be continuous (11: 46). A model could also be characterized as how it uses random variables. A deterministic model uses no random variables whereas a stochastic model contains one or more random variables (11: 3). All of these ideas could provide very descriptive, definitive traits for describing MS&A.

Personal Interviews

Another source of information for developing potential traits for the database was personal interviews and conversations with members of the Air Force MS&A community. The most productive were those interviews with Maj Steve Chimelski, the thesis sponsor from HQ AFMC/XRX, conversations with 1Lt Tim Ragsdale and Capt Bill Greer during a visit to the Space and Missile Center (SMC), telephone conversations with Mr. Bernie McKinney at Edwards AFB, and discussions with Mr. Richard J. Simard from the Rome Air Development Center Laboratory at Griffiss AFB.

Maj Chimelski recounted many past iterations with the goal of developing some mechanism to track the status of the AFMC MS&A assets. It is believed that such a tool would reduce yearly expenditures on developing new MS&A applications by reducing redundant applications. Most previous work centered around developing paper databases that were inconvenient to use, difficult to maintain, and provided no search capability (3). This led to the request for a database that would "allow the users to access the titles, short

descriptions, and POCs of the individual models and simulations" (4). Table 1 provides a brief recap of the last attempt to create a paper database to fulfill the needs of the AFMC MS&A community.

The interviews and information collected from the SMC in Los Angeles AFB, CA; the 412 Test Wing at Edwards AFB, CA; and Rome Air Development Center Lab at Griffiss AFB, NY show that there is great interest in having a database to track MS&A tools. All three of these organizations have developed their own databases and two of them have loaded their listings onto the Internet. Table 2 shows the data fields captured by each of these existing databases.

The fact that some of the AFMC organizations have already developed their own databases and that others are in the process of developing one shows that the AFMC MS&A community is keenly interested in having a MS&A database. However, the interest doesn't stop at AFMC because the DoD has also done some work in developing databases or catalogs to advertise their MS&A capabilities.

Table 1. Recap of the Previous AFMC MS&A Database Development Effort.

AFMC MODELS AND SIMULATIONS SURVEY	
FIELD	DEFINITION
1. Title	Name of the model or simulation
2. Model Owner/Maintainer	Name of Owner
3. Point of Contact	Name, Organization, and Phone
4. Purpose	Purpose of the model or simulation
5. Type: Choose one of these: Policy Theater Campaign Engagement Engineering/Component Support Database Probability Model Other (Specify)	Categorize by type of simulation
6. Functional Area Application: Choose one or more of the following: Analysis Research and Development Education, training, and Military Operations Test and Evaluation Production and Logistics Manpower and Personnel Other (Specify)	Categorize by functional area of application
7. Description	Describe the model or simulation
8. Verification, Validation, and Accreditation	Actions taken to obtain verification, validation, or accreditation on the model or simulation
9. Description	Description of model or simulation
10. Hardware	Hardware requirements of the model or simulation
11. Software	Software requirements of the model or simulation
12. Database	Database requirements of the model or simulation
13. Developer Air Force (Specify which agency) Other government Contractor	Agency which developed the model or simulation
14. Costs	Cost incurred in developing the model or simulation
15. Frequency and Ease of Use	Frequency and ease of use of the model or simulation

Table 2. Data Fields Captured in Existing AFMC Databases

FIELD	ROME	EDWARDS	SMC
Title	X	X	X
Purpose	X	X	
Type	X	X	
Functional Area of Application	X		
Description	X	X	X
Hardware	X	X	X
Software	X	X	X
Security Classification	X	X	
Database	X		
Network Capability	X		
Verification, Validation, & Accreditation	X		X
M&S OPR	X		
Developer	X		X
POC	X	X	X
Date Implemented		X	
Proponent		X	X
Construction		X	
Limitations		X	
Planned Improvements		X	
Input		X	
Outputs		X	
General Data		X	
Acronym			X
Aerospace Power			X
Air Force Hierarchy			X
Run Time			X
Cost			X
Set-up Time			X
Learning Time			X
Interface			X
Use			X
Documentation			X
Availability			X
Notes			X

DoD Efforts

This is an AFMC effort with a primary goal of cataloging AFMC MS&A assets. However, there are some DoD efforts which may impact future applications of this database. First, in conversations with AF/XOM it appears that the DoD is moving towards a unified format for describing the capabilities of M&S tools. It also seems likely that DoD may soon be starting a consolidated database of M&S assets through out the DoD. This effort may be overcome by DoD directions to conform to their structure and data requirements. However, at this point in time, no directions have been received. The Defense Simulation & Modeling Office (DMSO) maintains a number of catalogs on the Internet. As of June 95, there were nine catalogs covering the four services:

Air Force Studies and Analysis Agency (AFSAA) M&S Catalog
Ballistic Missile Defense Organization (BMDO) M&S Catalog
J-8 M&S Catalog
ARMY Models & Simulations: Army Integrated Catalog (MOSAIC)
US Air Force Rome Laboratory M&S Catalog
TRANSCOM System Model Catalog
Catalog of War Games, Training Games, and Combat Simulations
Navy Catalog of Models and Combat Simulations
USAF SMC/XR

There are some drawbacks to these catalogs. First, not all of the assets of each of the services are represented. Second, they only allow a key word search to determine applicable models and this capability is only available in seven of the nine catalogs. Another drawback is that each of the catalogs varies in content and amount of data given for an particular model. Even considering these drawbacks, the catalogs provide a service which is unavailable from any other source.

Summary

This chapter provides some background information needed to understand the importance and relevance of this research. We are dealing with a requirement to compile

and use data concerning AFMC's M&S assets, in other words we are dealing with an information system. The literature search reviewed the different types of information systems and basically identifies our system as being a Transaction Processing System (TPS). Given that we knew what kind of system we had, we addressed the requirements of the customer in terms of what they wanted. This led to a determination that a database would be the most suitable vehicle for recording the characteristics and traits of M&S. This led to a discussion of the steps involved in developing a database. However, the database is merely the proof of concept for the research emphasis of this thesis. We are interested in determining the important traits and characteristics of MS&A so that we can catalog and search AFMC's inventory. The first step of determining applicable traits was a search of the literature to see if any previous efforts had been done in this subject area. A few taxonomies exist for specialized applications of M&S, but nothing appears to have been done on an overall, unifying taxonomy scheme. Thus we basically need to start from scratch. We researched several regulations, instructions, and texts which discussed M&S. We also interviewed and visited with many current practitioners in the field. These sources will provide the basis for the research effort. Finally , we briefly covered the DoD's efforts because there is a potential chance that this effort may be overcome by a chain of events outside of AFMC's control.

III. Methodology

Chapter Overview

This chapter describes the processes that will be followed to achieve the objectives of identifying the different traits of MS&A, identifying which traits are most useful, and developing a database based on those most useful traits. We will address how each investigative question will be answered.

What Traits Differentiate One MS&A Program From Another?

The first investigative question addresses the issue of what differentiates one MS&A tool from another. In order to answer this question, a literature search was conducted to provide the basic foundation of terminology and usage. The literature search was broadened by interviews with field and headquarters personnel to define current Air Force aspects. The literature search and interviews suggested that there are many traits which could be useful for attempting to categorize MS&A applications. These avenues will be explored by identifying which traits are most useful in a database.

Which Traits Are Most Useful to Analysts in Selecting MS&A Software?

The second investigative question explores the usefulness of MS&A traits identified from the literature search and interviews. A briefing (Appendix A) was developed and presented to a panel of experts from all portions of the AFMC simulation community to elicit their ideas and concerns about this study. Based upon the results of the literature search, interviews, and discussions, a survey was developed to collect the AFMC MS&A community's thoughts on the usefulness of each potential trait. Part of the

survey uses a Likert scale to gauge a respondent's opinion of the usefulness of each item and the scores are totaled to measure the respondent's attitude (5: 179). The survey is shown in its entirety in Appendix B, but its construction is discussed here.

In order to understand the structure of the survey, I need to start with a brief discussion of MS&A as it applies to the development effort. The MS&A database is envisioned to have three main sections: models, databases, and analyses. Models are the actual programs or tools used by analyst to answer questions of interest. Examples are Thunder or TAC Brawler. Databases are the data files needed to run the models. In fact, some data files can be used interchangeably or provide input parameters in different models. Analysis is the study output addressing a particular problem or issue that uses a MS&A model and/or database. Analysis can consist of written reports, spreadsheets, or other like items.

The survey collects information on each proposed item including suggested field entries for a potential data item; whether or not the field should apply to one or more of the three main sections of the database (i.e., does it apply to Models, Databases, or Analyses); defining the usefulness of each potential field; and whether or not the field entries are mutually exclusive. Figure 9 displays an example of the survey for the potential database item of Title.

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE ?
1	Title	Text	M D A	1 2 3 4 5	Yes No

Figure 9. Example of Survey for Potential Field Entitled Title.

As displayed in Figure 9, the survey has six main columns:

1. ITEM: Numbers and groups the fields. Item also provides a tracking mechanism between the survey and the source document.

2. POTENTIAL FIELD: Name of the field and subelements, if any.

3. FIELD ENTRY: How the field would appear in the database. It could be a text entry or a coded entry. Where a field entry is given, it is only a suggestion. It may or may not be appropriate for the circumstances. In some instances, no suggestion is given and the subject's comments and recommendations are needed.

4. APPLY TO: Some potential fields may have application in all portions of the database (e.g. Title) whereas other fields may only apply to one portion of the database (e.g. Class of Simulation may only apply to Models). The three logical groupings thus far defined are:

   - Models: actual tool or software.

   - Databases: data files necessary to run the models.

   - Analyses: studies that have been done using a model.

   Any or all three of these may be appropriate for a given proposed field.

5. USEFULNESS: Ranking of subject's perception of the field's utility:

   1 = Extremely Useful, the database would not make much sense or have much utility without it.

   2 = Useful.

   3 = Marginally Useful, the field is of intermediate necessity.

   4 = Minimally Useful.

5 = Not Useful At All, it's a waste of time and space to have such a field.

6. EXCLUSIVE: Subject is to determine if the field can take on multiple values for a particular item. For instance, if the Class of Simulation is live, can it be constructive also? In some cases, mutual exclusion may be necessary or beneficial; in other cases it may not.

The results of this survey will provide the basis for defining the MS&A database. The responses to the survey will be analyzed to determine which potential traits are viewed by the MS&A community as being most needed in a database. Two main pieces of information will be obtained from the survey:

1. Each potential field will be evaluated as to whether or not it should be included in each section of the database (i.e. in the Model, Database, or Analysis section). This will be derived in a two step process. First, in order to be included, each field must yield an average value of 2.50 or less. The cutoff value of 2.50 was chosen because it is the midpoint between a rating of useful (2.00) and marginally useful (3.00). Second, a majority of respondents (50% or greater) must respond that the field would be useful for a particular section of the database. Let's suppose for instance that a potential field yields an average value of 2.00 with 7 out of 10 respondents for the Models section; an average value of 3.00 with 6 out of 10 respondents for the Database section; and an average value of 1.00 with 2 out of 10 respondents for the Analysis section. In this case, only the Models section would include the potential field. The Database section would not pass muster because it had an average greater than 2.50 (even though it had a 60% response rate) and the Analysis section would not pass muster because it only had a response rate of 20% (even though it had an usefulness rating of 1.00).

2. Each potential field will be evaluated as to whether or not it should be considered mutually exclusive. This is to say whether or not a potential field could use only one of the suggested field entries or more than one. The responses from the survey will be tabulated and a simple majority (i.e. 50% or greater) will determine whether or not the field should be mutually exclusive.

Once the results have been compiled and tabulated, we can take steps to start developing the prototype database.

Can a Database Based on a Cataloging System Which Uses Such Traits Provide Retrieval Performance for Users?

The last investigative question brings the first two questions together into a practical application. The intention is to create a prototype database to determine whether or not MS&A tools can be cataloged and whether or not that database can provide an acceptable retrieval capability. The AFMC MS&A database will be designed according to the steps outlined in Chapter 2, Literature Review. This four step process starts with identifying the requirement formulation and analysis for the database. Next we need to develop the conceptual design of the database and identify the relationships between the data. After that is completed, we develop a relational model, build a data dictionary, and design the prototype database. Last, the database's physical design is reviewed, but this step is not part of this thesis effort. However, an additional step of testing the prototype database will be accomplished.

Requirements Formulation and Analysis: Much of the need for an AFMC MS&A database is outlined in Chapter 1, Background and Problem Statement. In addition to realizing a potential savings from reducing duplication of effort, this database could be used as a vehicle to advertise the current capabilities of the AFMC MS&A

community. It could also be used as a research tool and as a tracking mechanism. The type of data collected will be the defining characteristics of MS&A software. Some such factors could be application type, weapon system, language, and hardware requirements. This information will come from the expert panel and will depend upon what they consider important and necessary. The information will be collected by means of a survey instrument sent to all members of the expert panel. The survey was discussed above and is found in its entirety in Appendix B. The resulting collected information will then form the basis of the database by defining the necessary fields.

Conceptual Design: The relationships between the data collected from the survey will be displayed in an Entity-Relationship (ER) Diagram. The results of this tool provide the basis for the conceptual model.

Implementation Design: Once the relational model is established, we can start developing the data dictionary, building the database, and inputting the data. The actual data source for populating the database will come from each of the labs using information collected in the 1993 catalog effort. Each of the labs and product centers submitted hardcopy catalogs of model descriptions which will be used to populate the Models section of the database. However, no information is available at this time to populate the Database and Analysis sections. We must compile the data, organize it, and input it into the prototype. After we have populated the database with the catalog information, we need to conduct some testing to ensure applicability and suitability of use.

Physical Design: This step is concerned with the operational efficiencies of the database design and is beyond the scope of this thesis. The prototype database is for proof of concept as to the usefulness of the MS&A traits used to develop the prototype database.

Testing: The last step of this effort consists of testing the database. After the database has been designed and partially populated, an inquiry screen will be developed and testing will begin. The test will be conducted by using potential users from one of the labs to evaluate the usefulness of the database. Each potential user will be asked about their most recent simulation experience. Based on that experience, they will be asked to use the prototype database to determine whether or not the application they used is identified by their query. They will be also asked to evaluate the other applications suggested by the database as to whether or not they would be useful in the user's particular problem area. They will also be asked about how they view the utility of the database. The prototype will be evaluated according to three criteria:

- Did the database suggest the model that the user had used in their simulation study (provided the model is in the prototype)?

- What is the perceived usefulness of the remaining suggested models (using a Likert scale similar to one used in the survey)?

- How satisfactory was the prototype (i.e. a utility rating using a Likert scale)?

Summary

This chapter provides the outline of the approach which will be taken to answer the investigative questions and to develop the MS&A database which will be used as proof of concept.

IV. Results

Chapter Overview

This chapter discusses the answers to the investigative questions posed in chapter 1. The first question "What traits differentiate one MS&A program from another?" was answered through the results of a literature search as discussed in chapter 2. The information from the literature search was synthesized into a survey which was described in chapter 3. The results of the survey and how the results provided the foundation for the database prototype will be discussed in this chapter. We will conclude with a test of the database and the final results.

Which Traits Are Most Useful to Analysts in Selecting MS&A Software?

This investigative question builds upon the first one; What traits differentiate one MS&A program from another? The literature search revealed that there are no high level, unifying taxonomies that can be used to answer this question. Thus a search of the relevant regulations, manuals, and texts along with interviews with current MS&A users provided a foundation to define which traits could possibly be most useful. A survey was developed, as discussed in chapter 3, which was sent out to 27 members of the Modeling and Simulation Technical Planning Integrated Product Team (M&S TPIPT) on 29 Jun 95. Return responses were requested by 14 Jul 95. The response rate was five surveys out of 27. Two additional respondents did not fill out the survey because they felt that their experience level was inappropriate and would bias the results. Through an attempt to contact all of the 27 members by phone, it was determined that two members of the TPIPT had been reassigned, thus reducing the size of the survey population to 25.

However, a 28% (7/25) response rate was viewed as being low. The TPIPT was meeting at Wright-Patterson AFB 20-21 Jul 95 and a second chance to promote the survey was arranged. Following the presentation, an additional 15 surveys were distributed (no members were double counted, i.e. only one survey was allowed per respondent). As a result, a total of 16 TPIPT members responded, 13 with completed surveys and three with general comments but incomplete surveys. This equates to a 40% response rate (16/40). Table 3 provides the results of identifying which traits the community feels are most useful in describing MS&A software. Appendix C is a spreadsheet that shows the individual responses and values which were used to determine the relevant fields represented in Table 3. As discussed in chapter 3, each potential field had to receive an average usefulness rating of 2.50 or less and be considered useful by more than 50% of the total respondents. If the potential field did not pass muster on either condition, then it was eliminated from further consideration. Appendix D is a spreadsheet that shows the individual responses concerning the mutually exclusive issue for an potential field. A simple majority was needed to determine whether or not a field is mutually exclusive or not. Without exception, all of the potential fields were determined to be <u>not</u> mutually exclusive. This means that for any potential field that has options or selections, a MS&A tool could be described by one or more of the options. Now that we know what fields are involved, we began the process of creating an MS&A database.

Can a Database Based on a Cataloging System Which Uses Such Traits Provide Retrieval Performance for Users?

We will answer this question by developing a prototype MS&A database. In Chapter 2, Literature Review, I outlined a four step process for developing a database;

Requirements Formulation and Analysis, Conceptual Design, Implementation Design, and Physical Design. A fifth step has been added for this effort which is testing the prototype.

Table 3: Fields Identified as Being Most Useful.

ITEM	POTENTIAL FIELD	MODEL	DATABASE	ANALYSIS
1	Title (Ex: AF Acquistion Model)	X	X	X
2	Acronym (Ex: AFAM)	X	X	X
3	Common Use of M&S	X	X	X
5	Data V V & C	X	X	
6	Class of Simulation	X		
7a	Source		X	
7b	Accuracy		X	
7c	Up-to-dateness		X	
7g	Security	X	X	X
7h	Releasability	X	X	X
8	Model V V & A	X		
9b	Interoperability	X	X	
9c	Reuse	X	X	
9d	Portability	X	X	
9e	Distributive Operation	X		
9f	Legacy Interface	X	X	
12	Distributed Interactive Simulation		X	
13	Fidelity	X	X	
14	M & S Interoperability	X	X	
16	Military Capability	X		X
18	Functional Area of Application	X	X	X
19	Distributed Operation	X	X	
21	Types of M & S	X		
23	AF Hierarchy	X		X
24	Hierarchy	X		
25	Static	X		
26	Dynamic	X		
27	Deterministic	X		
28	Stochastic	X		
29	Discrete	X		
30	Continuous	X		
31	Types of Platform	X	X	
32	Language	X		
33	Run Time	X		
36	Weapon System	X		
37	System Segment	X		
38	Limitations	X	X	X
40	OPR	X	X	X
41	Description	X	X	X
	TOTALS	35	22	11

Requirements Formulation and Analysis: This first step has been discussed in detail in previous sections of this thesis. We covered the need for an AFMC MS&A database in Chapter 1, Background and Problem Statement. We reviewed management reports, documentation, operating instructions, policy, guidance, and regulations; observed the workplace; and conducted interviews with users and managers. This collected information provided the basis for a survey that was constructed as described in Chapter 3, Methodology (the actual survey is contained in Appendix B). The results of the survey were discussed above in the section on answering the second investigative question. Having collected a basis of information and determined the need for the database, we were ready to proceed to the next step.

Conceptual Design: We will build upon the data collected in the first step of the design process. Our conceptional design will be built by using an Entity-Relationship (ER) model to format our data collected from the survey. Figure 10 shows the results of this tool which represents the basis for the conceptual model.

The model envisions four major entities; Models, Databases, Analyses, and Office. Models are capable of interacting with Databases and vice versa. This relationship is a many-to-many relationship which means each model can interact with many different databases and the reverse is true also; that is many databases can interact with many different models. This same situation exists between the Models to Analyses and Databases to Analyses relationships. The relationship shared between Office and the other three entities is a one-to-many. In the case of Models, this means that each model has only one Office that has the overall responsibility to maintain that model. However, each Office has the potential of maintaining more than one Model. This same concept holds true for the Office to Databases and Office to Analyses relationships.

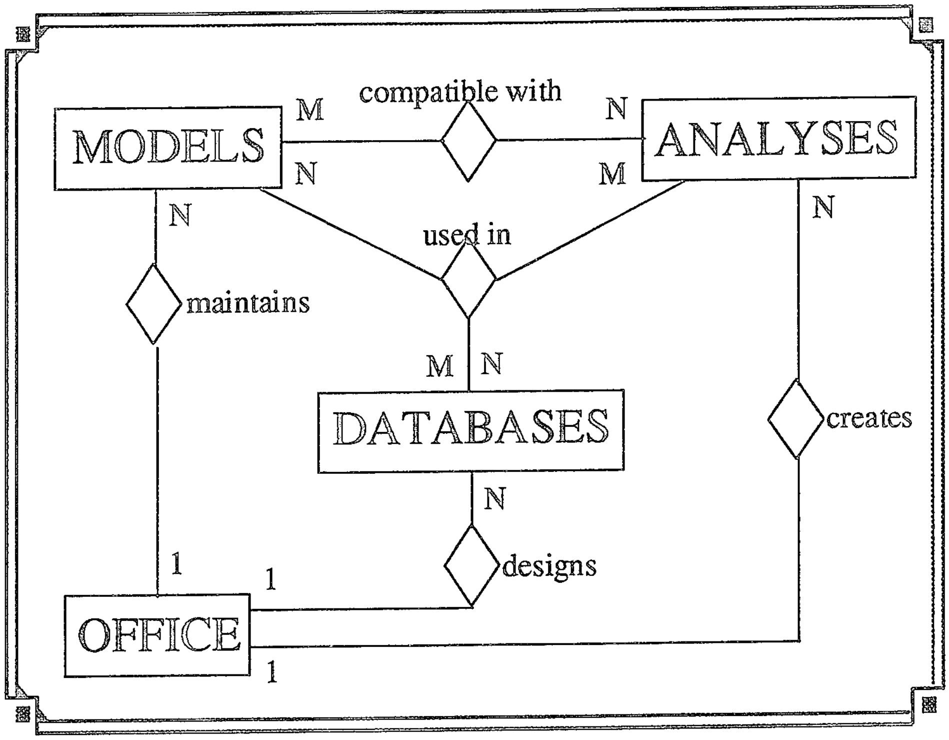


Figure 10. ER-Model of the Prototype Database.

Given that we know the relationships shared amongst the data, we can define the fields that will be an inherent part of each entity. Appendix E is the data dictionary which contains the names, length, type of data, and definition for each field in the Models and Office tables (i.e. the entities have been directly translated into tables for the prototype database).

Implementation Design: Using the results of the ER model, we defined the relational model and established the data dictionary. Once the relational model was established, we started inputting the data. The data source for populating the database came from each of the labs using information collected in the 1993 catalog effort. Each of the labs and product centers had submitted hardcopy catalogs of model descriptions to HQ AFMC for a previous effort. This was used to populate the Models and Office section of the database. However, there were a few major problems with this data source. First, no

information was available to populate the Database and Analysis sections. Second, the survey identified new information requirements for the Models table (such as defining the class of simulation, the military capability rating, and type of M&S to name a few). The Models table has 84 fields used to describe M&S models or tools. These fields can be further segmented as being either descriptive or selective. For instance, the fields like Model_Title and Model_Descrip could be viewed as descriptive. However, fields like Model_Func_Area_R&D or Model_Weapon_Fighter are selective. Selective means one can choose a model based on desired characteristics. All of the selective fields were defined to be Yes/No fields which allows for multiple selection in a particular field category (such as AF Hierarchy, Functional Area of Application, or Class of Simulation). Table 4 shows the Models descriptive fields and Table 5 shows the Models selective fields arranged by categories.

Table 4. Models Descriptive Fields.

MODEL_TITLE	MODEL_VERSION_NUMBER
MODEL_ACRONYM	MODEL_DUTYORG
MODEL_OFFICE_SYMBOL	MODEL_COMMON
MODEL_DATA_VVC_DATE	MODEL_DATA_VVC_CODE
MODEL_SECURITY_LEVEL	MODEL_RELEASE
MODEL_VER_DATE	MODEL_VER_AGENCY
MODEL_VAL_DATE	MODEL_VAL_AGENCY
MODEL_ACCRED_DATE	MODEL_ACCRED_AGENCY
MODEL_REUSE	MODEL_PORTABILITY
MODEL_LEGACY	MODEL_FIDELITY
MODEL_M&S_INTEROP	MODEL_DISTRIBUTED_OPS
MODEL_PLATFORM	MODEL_LANGUAGE
MODEL_RUN_TIME	MODEL_LIMITS
MODEL_DESCRIP	

Table 5. Models Selective Fields.

CLASS OF SIMULATION
- MODEL_CLASS_LIVE
- MODEL_CLASS_VIRTUAL_HUMAN
- MODEL_CLASS_VIRTUAL_PROTO
- MODEL_CLASS_CONSTRUCTIVE
- MODEL_FUNC_AREA_ANAL

TYPE OF M&S
- MODEL_TYPE_WARGAME
- MODEL_TYPE_TRAIN
- MODEL_TYPE_ACQ

MILITARY CAPABILTY
- MODEL_MILCAP_READINESS
- MODEL_MILCAP_MODERN
- MODEL_MILCAP_FORCE
- MODEL_MILCAP_SUSTAIN

WEAPON SEGMENT
- MODEL_WEAPON_FIGHTER
- MODEL_WEAPON_TANKER
- MODEL_WEAPON_TRANSPORT
- MODEL_WEAPON_BOMBER
- MODEL_WEAPON_HELI
- MODEL_WEAPON_SATELITE
- MODEL_WEAPON_MISSILE
- MODEL_WEAPON_COMMAND
- MODEL_WEAPON_OTHER
- MODEL_SYSTEM_COMPUTER

INTERNAL CHARACTERISTICS
- MODEL_STATIC
- MODEL_DYNAMIC
- MODEL_DETERMIN
- MODEL_STOCHASTIC
- MODEL_DISCRETE
- MODEL_CONTINUOUS

STANDALONE CAPABILITY
- MODEL_STANDALONE

FUNCTIONAL AREA OF APPLICATION
- MODEL_FUNC_AREA_EDUC
- MODEL_FUNC_AREA_TRAIN
- MODEL_FUNC_AREA_MIL_OPS

- MODEL_FUNC_AREA_R&D
- MODEL_FUNC_AREA_T&E
- MODEL_FUNC_AREA_PROD
- MODEL_FUNC_AREA_LOG
- MODEL_FUNC_AREA_DESIGN

AF HIERARCHY
- MODEL_AF_HIER_STRATEGY
- MODEL_AF_HIER_THEATER
- MODEL_AF_HIER_MISSION
- MODEL_AF_HIER_ENGAGE
- MODEL_AF_HIER_SYSTEM

SYSTEM SEGMENT
- MODEL_SYSTEM_AVIONIC
- MODEL_SYSTEM_NAV
- MODEL_SYSTEM_RADAR
- MODEL_SYSTEM_COMM
- MODEL_SYSTEM_WEAPON
- MODEL_SYSTEM_MISSILE
- MODEL_SYSTEM_INTEL

- MODEL_SYSTEM_COST
- MODEL_SYSTEM_PROPULSION
- MODEL_SYSTEM_STRUCTURE
- MODEL_SYSTEM_OTHER

ROLES OF AEROSPACE POWER
- MODEL_ROLES_CONTROL
- MODEL_ROLES_APPL
- MODEL_ROLES_ENHANCE
- MODEL_ROLES_SUPPORT

Unfortunately these new information requirements were the foundation for establishing any kind of search capability. Assistance was rendered by Captain Ken Scribner, Mr. Brian Stadler, and Mr. Joe Nalepka from Wright Labs (WL) in identifying the appropriate coding for the a few select WL models in the 1993 catalog. This was necessary because without defining the models in terms of their search characteristics, it would have been impossible to test the concept of the prototype database. The database was populated with over 300 Models and over 80 Office entries. Once the population of the database was completed, we started on designing the questionnaire for the test.

Physical Design: This step is concerned with the operational characteristics of the database design and is beyond the scope of this thesis. The prototype database is for proof of concept as to the usefulness of the MS&A traits; not as a completed, operational database.

Testing: The last step in the process was a test of the prototype to gain an indication of how well the prototype performed in the view of the potential users. After the database was designed and partially populated, testing began. Each potential user tried the prototype to obtain a list of models which may have been applicable to their last M&S application and completed a questionnaire (Appendix F) to describe the results of their search. As part of the questionnaire, each potential user was asked about their most recent simulation experience. Based on that experience, they were asked to use the prototype database to determine whether or not the application they used was identified by their query. Additionally, they were asked to evaluate the other applications suggested by the database as to whether or not they would be useful in the user's particular problem area. Last, they were asked about how they viewed the utility of the database.

The prototype was evaluated according to three criteria:

- Did the database suggest the model that the user had used in their simulation study (provided the model is in the prototype)?
- What is the perceived usefulness of the remaining suggested models?
- How satisfactory was the prototype?

It was anticipated that the questionnaire would be administered to a small sample of six M&S users. However, after administering the questionnaire to three individuals and obtaining no usable results, the test was terminated. In all three cases, the users did not obtain any outputs (i.e. the prototype failed to return any potential titles). First, the models that the users had worked with were not in the database, thus the answer to the first question was no. The second question went unanswered because no titles were suggested, thus a rating on their usefulness was impossible. Finally, the last question was answered with a favorable result. The subjects' average rating for the prototype was 2 which translates into a rating of useful. This was a heartening result given that the prototype failed to yield any tangible results. All three respondents believe that the database could be a useful tool once it is expanded and updated.

The database was not sufficiently populated nor specified to allow for a useful test. Of the 306 records contained in the Models table, only 53 have been fully specified to include some inputs for the new information requirements. This information must be acquired and entered for all 306 records before profitable testing can be accomplished.

Summary

This chapter has covered the results of the survey, construction of the prototype database, and the test results on the prototype. The survey did suggest that there are many characteristics that MS&A users would be interested in knowing. Based on these characteristics, the database structure was defined through the analysis of an ER-Model and was translated into the database structure. Once the database structure was defined, the database was populated and testing was started. Although the results of the test were disappointing, there are reasons why the test failed. Once these reasons are addressed, then a meaningful test of the prototype database can be conducted.

V. Conclusions and Recommendations

Chapter Overview

This chapter is the culmination of the study. Herein are presented the conclusions and recommendations.

Conclusions

This study has been a worthwhile effort. It has shown that the MS&A community is indeed interested in establishing a database that is a repository of MS&A holdings within AFMC. This study has been successful in identifying and establishing useful characteristics of MS&A to allow for a selective and descriptive approach to cataloging MS&A models, databases, and analyses. Without doubt, we have been successful in our endeavors of addressing the first two investigative questions. However, when it came to the testing of the prototype database, we met with failure. But, this failure is not without cause. Much of the data upon which the success of the test hinged was either out of date or nonexistent. It is believed that the MS&A database can provide the capabilities the AFMC MS&A community needs; namely a method to track their current inventory and to provide access to their modeling and simulation capabilities in definitive terms never before available. The following are some recommendations or suggestions which will take the database from prototype to reality.

Recommendations

1. **Populate and Update the Prototype:** Much of the information currently contained in the prototype is based on information from a 1993 AFMC effort. However, much of this information is outdated: some models are no longer used or are outdated and other models that are currently used are not listed. This update procedure can be

incorporated with the populating of the database by designing a database form which could allow for the direct transfer of information from the form into the database. Multiple forms will be necessary to allow for updating each of the main tables; i.e. Models, Office, Databases, and Analyses. By automating these forms, the data will already be appropriately formatted for inclusion into the database and will reduce the level of effort associated with collecting the data and updating the database.

2. Develop Forms for the Query and Report Functions: The prototype relied on the inherent query capabilities of Access. This function can be improved and made transparent to the user by means of a query form or macro which will allow an intuitive selection of models, databases, or analyses. This query form would provide the user the ability to select search criteria and specify and/or relationships by means of selecting the appropriate buttons on the form and then the macro will develop and run the query.

3. Select Platform or Mode of Access: The MS&A community needs to decide which platform they desire for the database. For instance, the database could be mounted on a mainframe or could be PC based. Once this is decided, the method of transmission or access needs to be determined. If the mainframe option is used, then the only reasonable method of access would be real time because no user would wish to use the database by having to submit a written request and wait for a response. If the PC option is selected, then the community has a number of alternatives. Updates to the database could be made periodically and distributed on floppy disk or on CD ROM. Or the database could be mounted on a server and access could be made via DSN, bulletin board, or Internet hookups. Just having the database is not enough, the product needs to be accessible through the community in a timely fashion to be of any significant use.

4. Select an Overall Office or Organization of Primary Responsibility (OPR): Someone needs to be primarily responsible for the maintenance and oversight of this command wide database. Administrative functions and improvements will need to be done on a recurring basis and someone will need to do them. The Modeling and Simulation Technical Planning Integrated Product Team (M&S TPIPT) would be a likely candidate. They are already active with membership throughout the command and are responsible for M&S issues within AFMC. This database could contribute to their oversight and planning functions. Updates and changes to the database could be discussed, approved, and implemented in conjunction with their periodic meetings.

5. Establish an Archive for Models, Databases, and Analyses: Not all models, databases, or analyses will remain current. Over time they will become outdated or superseded. However, that is not to say that a review of past findings, studies, models, etc. may not be beneficial. At this point in time each organization has the responsibility for maintaining their own products. What is suggested is that an archive be developed, so that when a model is identified as being outdated it can be forwarded to the archive for potential future research or use.

Summary

This chapter has addressed the conclusion of this thesis and suggested five follow on activities or issues which need to be addressed. Participants in this research showed great support for creation of a comprehensive taxonomy and subsequent development of a database system for Modeling, simulation, and Analysis products. Such a database has great potential for identifying redundant development efforts, helping AFMC maintain its

MS&A inventory, and providing a vehicle for the crossflow of information both within and outside AFMC.

APPENDIX A

BRIEFING

MODELING, SIMULATION, & ANALYSIS (MS&A) DATABASE DEVELOPMENT EFFORT

Capt Tim Wagner
AFIT/LAA

MS&A DATABASE OVERVIEW

- Problem Statement
- Study Goals
- Previous Effort
- Conceptual View
- Other Considerations

MS&A DATABASE PROBLEM STATEMENT

- AF Expenditure of $60 -70 million/year
- Duplication of MS&A functions (50-60%)
- Diverse applications of MS&A
- Numerous, independent locations
- No centralized catalogue of MS&A
- Little coordination of development efforts

MS&A DATABASE STUDY GOALS

- Identify useful characteristics and traits
- Design a classification system for MS&A
- Identify user needs & operating parameters
- Develop a MS&A database
- Develop a retrieval protocol to identify specific MS&A

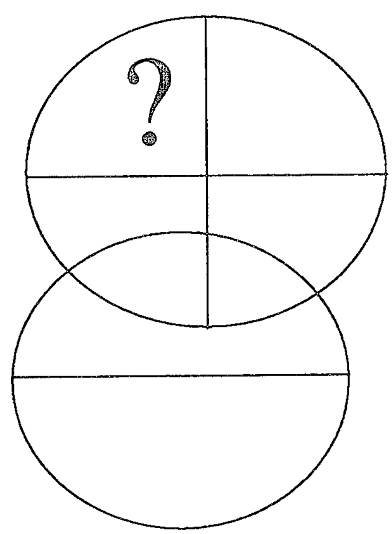
MS&A DATABASE PREVIOUS EFFORT

- HQ AFMC spearheaded consolidation effort
- Results (sample breakout):

  Title; Model Owner/Maintainer; Type; Functional Area of Application; Description; Verification, Validation, and Accreditation; Hardware; Software; Database; Developer; Costs; Point of Contact; Frequency and Ease of Use; etc.

MS&A DATABASE CONCEPTIONAL VIEW

- How do we cut the pie
- By Type?
  - Theater
  - Campaign
  - Mission
  - Engagement/Submission
  - System/Subsystem/Component
  - Support
  - Database
  - Functional
  - Other



MS&A DATABASE END GOAL

- Program Manager: " I want to find any MS&A dealing with _______"
  - F-16 performance
  - probability models
  - risk analysis
  - weapons performance
- And the database would yield a concise list of MS&A possibilities.

MS&A DATABASE OTHER CONSIDERATIONS

- Use as info only or decision making
- Collect cost data
- PC or mainframe based
- Distributed or centralized
- Other

APPENDIX B

SURVEY

TO: Members of the M&S TPIPT 19 Jul 95

SUBJECT: AFMC MS&A Database

FROM: AFIT/LAA (Capt Wagner)

1. I am soliciting your input, via the included survey, on what database fields would be most beneficial in developing an AFMC MS&A database. Potential fields were compiled from numerous sources, however the survey is by no means a complete and exhaustive list. You have been chosen to participate by virtue of your membership on the M&S TPIPT and your recognized expertise in the field. As you may recall, all attendees of the 8-9 Mar 95 M&S TPIPT meeting were briefed on a thesis addressing this issue and this survey is a necessary and vital part of that effort.

2. You should have received three attachments to this letter; an instruction sheet covering the survey; the survey; and a source document which details where each potential field came from. Please take a few minutes to review the survey, circle your responses, and provide the results to me at end of the conference. I will be at your disposal to answer any questions during Thursday morning or all day Friday. Thank you for your assistance.

TIMOTHY J. WAGNER, Capt, USAF

MS&A DATABASE SURVEY INSTRUCTIONS

The MS&A database is envisioned to have three main sections: models, databases, and analysis. Models are the actual programs or tools used by analyst to answer questions of interest. Examples are Thunder or TAC Brawler. Databases are the data files needed to run the models. In fact, some data files can be used interchangeably or provide input parameters in different models. Analysis is the study output addressing a particular problem or issue that uses a MS&A model and/or database. Analysis can consist of written reports, spreadsheets, or other like items.

For each potential field, you will be asked to do the following:

1. Suggest a field entry for some potential fields.
2. Identify the applicability of the potential field to models (M), databases (D), and/or analysis (A). Any or all may be circled. For example, "Title" would likely have all three circled while "Class of Simulation" may only have "M" circled.
3. Rank the usefulness of each potential field as to its utility in an MS&A database. A ranking of 1 means that the potential field would be a needed and integral part of the database. Conversely, a ranking of 5 means that the field would be unnecessary. Only one number should be circled.
4. Identify whether or not the field entry codes would be mutually exclusive or more than one field entry code could apply to a potential field.

The survey has six main columns:

ITEM: Numbers and groups the fields. Item also provides a tracking mechanism between the survey and the source document.

POTENTIAL FIELD: Name of the field and subelements, if any.

FIELD ENTRY: How the field would appear in the database. It could be a text entry or a coded entry. Where a field entry is given, it is only a suggestion.

It may or may not be appropriate for the circumstances. In some instances, no suggestion is given and your comments and recommendations are needed.

APPLY TO: Some potential fields may have application in all portions of the database (such as Title) whereas other fields may only apply to one portion of the database (such as Class of Simulation may only apply to Models perhaps). The three logical groupings thus far defined are:

- Models: actual tool or software.
- Databases: data files necessary to run the models.
- Analysis: studies that have been done using a model.

Any or all three of these may be appropriate for a given proposed field.

USEFULNESS: This is a ranking of how useful you view a field:

1 = Extremely Useful, the database would not make much sense or have much utility without it.

2 = Useful.

3 = Marginally Useful, the field is of intermediate necessity.

4 = Minimally Useful.

5 = Not Useful At All, its a waste of time and space to have such a field.

EXCLUSIVE: This column is basically asking whether or not the field is mutually exclusive. For instance, if the Class of Simulation is live, can it be constructive also? In some cases, mutual exclusion may be necessary or beneficial; in other cases it may not.

EXAMPLE:

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE?
1	Title	Text	M D A	1 2 3 4 5	Yes No

A Title would be used in each portion of the database for naming the models, databases, and studies. The usefulness of such a field is extremely important and the titles do not necessarily have to be mutually exclusive.

Your participation in this survey is voluntary. Your name and responses will be held strictly confidential. Should you have any questions, comments, suggestions, or recommendations about a particular field, just jot down your thoughts on a separate piece of paper if there isn't enough room on the survey. If you have any additions, please submit those also. When you are finished with your survey, please give it to me at the end of the conference. Should you wish to provide any other information after the completion of the conference, my phone number is DSN 785-7777 ext. 2217, my E-mail address is twagner@afit.af.mil., and my fax number is DSN 986-7988 or commercial 513-476-7988. Thank you for your assistance.

TIMOTHY J. WAGNER, Capt, USAF
GCA-95S

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE
1	Title (Ex: AF Acquisition Model)	Text	M D A	1 2 3 4 5	Yes No
2	Acronym (Ex: AFAM)	Text	M D A	1 2 3 4 5	Yes No
3	Common Use of M&S	S = Sole Service J = Joint	M D A	1 2 3 4 5	Yes No
4	Complex Data	Hd = Highly derived data Mi = Obj of multiple inheritance Co = Compositions Ar = Artifacts of legacy systems	M D A	1 2 3 4 5	Yes No
5	Data V V & C	Ve = Verified Va = Validated Ce = Certified	M D A	1 2 3 4 5	Yes No
6	Class of Simulation	Li = Live Vh = Virtual, Human Vp = Virtual, Prototype Co = Constructive	M D A	1 2 3 4 5	Yes No
7	Data Quality consisting of:				
7a	Source	Text	M D A	1 2 3 4 5	Yes No
7b	Accuracy	Suggestions?	M D A	1 2 3 4 5	Yes No
7c	Up-to-dateness	Suggestions?	M D A	1 2 3 4 5	Yes No

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE
7d	Logical Consistency	Suggestions?	**M D A**	**1 2 3 4 5**	**Yes No**
7e	Completeness	Suggestions?	**M D A**	**1 2 3 4 5**	**Yes No**
7f	Clipping Indicator	Suggestions?	**M D A**	**1 2 3 4 5**	**Yes No**
7g	Security	N = Not classified F = For official use only R = No foriegn nationals L = Limited distribution	**M D A**	**1 2 3 4 5**	**Yes No**
7h	Releasibility	P = Public release, unlimited G = Government agencies only D = DoD only N = No release to contractors	**M D A**	**1 2 3 4 5**	**Yes No**
8	Model V V & C	Ve = Verified Va = Validated Ac = Accredited	**M D A**	**1 2 3 4 5**	**Yes No**
9	High Level Architecture Goals:				
9a	Entity level representation	Suggestions?	**M D A**	**1 2 3 4 5**	**Yes No**
9b	Interoperability	Y = Yes N = No	**M D A**	**1 2 3 4 5**	**Yes No**
9c	Reuse	Y = Yes N = No	**M D A**	**1 2 3 4 5**	**Yes No**
9d	Portability	Suggestions?	**M D A**	**1 2 3 4 5**	**Yes No**

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE
9e	Distributive operation	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
9f	Legacy interface	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
9g	Scalability	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
9h	Technological evolution	Suggestions?	M D A	1 2 3 4 5	Yes No
9i	COTS/GOTS use	C = COTS G = GOTS	M D A	1 2 3 4 5	Yes No
10	Aggregation Capable	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
11	Disaggregation Capable	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
12	Distributed Interactive Simulation:	Adr = Adv Concepts & Reqts Mil = Military Operations Rda = Research, Dev & Acq Trg = Training	M D A	1 2 3 4 5	Yes No
13	Fidelity	H = High M = Medium L = Low	M D A	1 2 3 4 5	Yes No
14	M & S Interoperability	Y = Yes N = No	M D A	1 2 3 4 5	Yes No

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE
15	Resolution	Suggestions?	M D A	1 2 3 4 5	Yes No
16	Military Capability	R = Readiness M = Modernization F = Force Structure S = Sustainability	M D A	1 2 3 4 5	Yes No
17	Scalability	Suggestions?	M D A	1 2 3 4 5	Yes No
18	Functional Area of Application:	E = Education T = Training M = Military operations A = Analysis R = Research & development T = Test & evaluation P = Production L = Logistics D = Design	M D A	1 2 3 4 5	Yes No
19	Distributed Operation	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
20	M & S Dimensions	R = Level of resolution H = Deg of human participation E = Deg of equipment realism T = Time management method S = Time step resolution D = Degree of distribution C = Computational complexity	M D A	1 2 3 4 5	Yes No

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE
21	Types of M & S	W = Wargaming T = Training A = Acquisition	M D A	1 2 3 4 5	Yes No
22	System Acquisition Process	R = Requirements generation A = Acquisition management P = Plan, Prog & Budget Sys	M D A	1 2 3 4 5	Yes No
23	AF Hierarchy	St = Strategic/National Th = Theater/Campaign Mi = Mission En = Engagement/Submission Sy = Sys/Subsys/Component	M D A	1 2 3 4 5	Yes No
24	Hierarchy	Th = Theater/Campaign Mi = Mission/Battle En = Engagement Eg = Engineering	M D A	1 2 3 4 5	Yes No
25	Static	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
26	Dynamic	Y = Yes N = No	M D A	1 2 3 4 5	Yes No
27	Deterministic	Y = Yes N = No	M D A	1 2 3 4 5	Yes No

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE
28	Stochastic	Y = Yes N = No	**M D A**	**1 2 3 4 5**	**Yes No**
29	Discrete	Y = Yes N = No	**M D A**	**1 2 3 4 5**	**Yes No**
30	Continuous	Y = Yes N = No	**M D A**	**1 2 3 4 5**	**Yes No**
31	Types of Platform	PC = Personal Computer MF = Main Frame Others?	**M D A**	**1 2 3 4 5**	**Yes No**
32	Language	Ba = Basic Fo = FORTRAN Co = COBOL Sl = Slam Si = Simscript Others?	**M D A**	**1 2 3 4 5**	**Yes No**
33	Run Time	XX min = Number of minutes XX hrs = Number of hours XX day = Number of days	**M D A**	**1 2 3 4 5**	**Yes No**
34	Roles of Aerospace Power	Ac = Aerospace control Fa = Force application Fe = Force enhancement Fs = Force support	**M D A**	**1 2 3 4 5**	**Yes No**
35	Joint M&S	S = Sole Service J = Joint F = Foriegn	**M D A**	**1 2 3 4 5**	**Yes No**

ITEM	POTENTIAL FIELD	FIELD ENTRY	APPLY TO	USEFULNESS	EXCLUSIVE
36	Weapon System	Fa = Fighters Ta = Tankers Bo = Bombers Sa = Satelites Mi = Missiles Others?	M D A	1 2 3 4 5	Yes No
37	System Segment	Av = Avionics Na = Navigation Co = Communications We = Weapons Mi = Missiles Others?	M D A	1 2 3 4 5	Yes No
38	Limitations	Text	M D A	1 2 3 4 5	Yes No
39	Frequency of Use	Da = Daily Wk = Weekly Mo = Monthly Yr = Yearly	M D A	1 2 3 4 5	Yes No
40	OPR	Text to include name and phone	M D A	1 2 3 4 5	Yes No
41	Description	Text	M D A	1 2 3 4 5	Yes No
42	Domain	A = Air L = Land S = Sea	M D A	1 2 3 4 5	Yes No

EXPLANATION OF SURVEY ITEMS

SOURCES. Each citation is taken, verbatim, from the referenced sources below. After each citation, the source (i.e. A, B, C, or D) and the associated page reference is given in parenthesis:

A. Under Secretary of Defense (Acquisition and Technology), DoD 5000.59-Paa, Modeling and Simulation (M&S) Master Plan (Draft), January 1995.

B. Colonel Lalit K Piplani, Lt Colonel Joseph G. Mercer, and Lt Colonel Richard O. Roop, Systems Acquisition Manager's Guide for the Use of Models and Simulation, September 1994.

C. Averill M. Law and W. David Kelton, Simulation Modeling and Analysis, c1982.

D. Ragsdale, Tim 1Lt and Greer, William Capt. SMC/XRES, Los Angles AFB, CA. Personal Interview, 20 - 24 Mar 1995.

CITATIONS (ordered as they appear in the survey):

1. TITLE. The title of the MS&A tool, database, or analysis. (D).

2. ACRONYM. The acronym associated with the title of the MS&A tool, database, or analysis, if any. (D).

3. COMMON-USE M&S. M&S applications, services, or materials provided by a DoD Component to two or more DoD Components. (DoDD 5000.59) (A, page ix).

4. COMPLEX DATA. Data that cannot be characterized as a single concept, atomic data element as defined in DoD 8320.1-M-1. Complex data includes most scientific and technical data. It has been recently categorized by the Complex Data Task Force into (a) highly derived data (e.g., probability hit/kill); (b) objects utilizing the concepts of multiple inheritance (e.g., student-assistant is subclass of student class and employee class), multiple root hierarchies (e.g., a tank is a vehicle and a tank is a weapon where "vehicle and "weapon" are each roots), and polymorphic attributes (e.g., "capacity" for different types of aircraft may mean number of people, pounds of cargo, or gallons of fuel); (c) compositions such as command hierarchies, road networks, images (binary large objects (BLOBS)), compound documents; and (d) artifacts of legacy systems and physical constraints (e.g., aircraft category and mission in

one data element, intelligence facility code where the first few bytes define how the rest of the field is used). (Eight I/DBTWG Conference. July 1994) (A, page ix).

5. DATA VERIFICATION, VALIDATION, & CERTIFICATION (VV&C). The process of verifying the internal consistency and correctness of data, validating that it represents real world entities appropriate for its intended purpose or an expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives: producer and user process. (A, page x).

a. DATA VERIFICATION. Data producer verification is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. Data user verification is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly. (Eight I/DBTWG Conference, July 1994). (A, page xi).

b. DATA VALIDATION. The documented assessment of data by subject area experts and its comparison to know or best-estimate values. Data user validation is that documented assessment of data as appropriate for use in an intended model. Data producer validation is that documented assessment within stated criteria and assumptions. (Eight I/DBTWG Conference, July 1994). (A, page xi).

c. DATA CERTIFICATION. The determination that data have been verified and validated. Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage. Data producer certification is the determination by the data producer that data have been verified and validated against documented standards or criteria. (Eight I/DBTWG Conference, July 1994). (A, page x).

6. CLASS OF SIMULATION. The categorization of simulation into live, virtual, and constructive is problematic, because there is no clear division between these categories. The degree of human participation in the simulation is infinitely variable, as is the degree of equipment realism. This categorization also suffers by excluding a category for simulated people working real equipment (e.g., smart vehicles). (A, page xiii).

a. LIVE SIMULATION. A simulation involving real people operating real systems. The categorization of simulation into live, virtual, and constructive is problematic, because there is no clear division between these categories. The degree of human participation in the simulation is infinitely variable, as is the degree of human participation in the simulation is infinitely variable, as is the degree of equipment realism. The categorization also suffers

by excluding a category for simulated people working real equipment (e.g. smart vehicles). (A, page xiii).

b. VIRTUAL SIMULATION. A simulation involving real people operating simulated systems. Virtual simulations inject human-in-the-loop (HITL) in a central role by exercising motor control skills (e.g., flying an airplane), decision skills (e.g., committing fire control resources to action), or communication skills (e.g., as members of a C41 team). (A, page xiii).

b.(1). HUMAN-IN-THE LOOP. Virtual simulation brings the system (or subsystem) and its operator together in a synthetic, or simulated environment. Although this document uses the term human-in-the-loop to represent these simulations, other names include man-in-the-loop, warfighter-in-the-loop, or person-in-the-loop. (B, page 4-3).

b.(2). VIRTUAL PROTOTYPES. A more advanced concept for virtual simulation is on our doorstep-- virtual prototyping. In this realm, a three-dimensional electronic, virtual mockup, of system or subsystem allows an individual to interface with a realistic computer simulation within a synthetic environment. (B, page 4-3).

c. CONSTRUCTIVE MODEL OR SIMULATION. Models and simulations that involve simulated people operating simulated systems. (A, page xiii).

7. DATA QUALITY. The correctness, timeliness, accuracy, completeness, relevance, and accessibility that make data appropriate for use. (Defense Data Repository System (DDRS) end-user manual, 24 August 1992) Quality statements are required for source, accuracy (positional and attribute), up-to-dateness/currency, logical consistency, completeness (feature and attribute), clipping indicator, security classification, and releasability. (The Digital Geographic Information Exchange Standard (DIGEST), Edition 1.2. January 1994). (A, page x).

8. MODEL VERIFICATION, VALIDATION, AND ACCREDITATION (VV&A).

a. ACCREDITATION. The official certification that a model or simulation is acceptable for use for a specific purpose. (DoDD 5000.59). (A, page viii).

b. VALIDATION. The process of determining the extent to which a model or simulation is an accurate representation of the real world from the perspective of the intended use(s) of the model or simulation. (DoDD 5000.59). (A, page xvi).

c. VERIFICATION. The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques. (DoDD 5000.59). (A, page xvii).

9. TECHNICAL GOALS FOR THE HIGH-LEVEL ARCHITECTURE. A set of ten technical goals for the high-level simulation architecture, corresponding to general capabilities desired for simulation systems, is as follows: (A, page A-2).

a. Entity-Level Representation. The simulation represents entities that are appropriate to observation by the intended end user.

b. Interoperability. Appropriate simulations and C4I systems operate in concert by exchanging information with one another.

c. Reuse. Components of one simulation can be used in another appropriate simulation.

d. Portability. The simulation can be run on a variety of computing platforms.

e. Distributed Operation. Operation of the simulation can be spread across several platforms, if need be, particularly to collocate simulation assets with geographically dispersed users.

f. Legacy Interface. New simulations will interoperate with some selected set of existing simulations.

g. Scalability. The architecture for the simulation allows appropriate growth in the number of entities accommodated, their types, and their level of resolution.

h. Broad Functional Applicability. The architecture developed for simulations for one functional purpose (e.g. training) is extendible for other functional purposes (e.g., analysis), where appropriate.

i. Technological Evolvability. The architecture for simulation allows new technologies to be used in the simulation as they become available.

j. COTS/GOTS Use. The architecture enables maximum feasible use of commercial off-the-shelf (COTS) and government off-the-shelf (GOTS) products.

10. AGGREGATION. The ability to group entities while preserving the effects of entity behavior and interaction while grouped. (Proceedings of Conference on Variable-Resolution Modeling, Washington, DC, Ed. Paul Davis and Richard Hillestad, May 1992). (A, page viii).

11. DISAGGREGATION. The ability to represent the behavior of an aggregated unit in terms of its component entities. If the aggregate representation did not maintain state representations of the individual entities, then the decomposition into the entities can only be notional. (A, page xi).

12. DISTRIBUTED INTERACTIVE SIMULATION (DIS). (1) Program to electronically link organizations operating in the four domains: advanced concepts and requirements; military operations; research, development, and acquisition; and training. (A, page xii).

13. FIDELITY. The accuracy of the representation when compared to the real-world. (A, page xii).

14. M & S INTEROPERABILITY. The ability of a model or simulation to provide services to, and accept services from, other models and simulations, and to use the services so exchanged to enable them to operate effectively together. (DoDD 5000.59). (A, page xv).

15. RESOLUTION. The degree of detail and precision used in the representation of real-world aspects in a model or simulation; granularity. (A, page xvi).

16. MILITARY CAPABILITY. Future M&S Support to the Four Pillars of Military Capability. M&S can substantially improve capability and decision making in each of the four pillars of military capability: (1) readiness, (2) modernization, (3) force structure, and (4) substainability. There are very challenging aspects to these descriptions, and achieving full capabilities will require long-term, systematic, coordinated efforts across DoD. (A, page 2-3, para C.).

17. SCALABILTY. The ability of a distributed simulation to maintain time and spatial consistency as the number of entities and accompanying interactions increase. (The DIS Vision, Version 1, May 1994). (A, page xvi).

18. FUNCTIONAL AREA OF APPLICATION. ...It includes all types of models and simulations and embraces the full range of M&S interaction between the scope of the simulation, sponsoring component objectives and functional area requirements (e.g. education, training and military operations; analysis; research and development; test and evaluation; production and logistics). ...to conduct research, development, test and evaluation activities while also using advanced simulations for design, manufacturing, and logistical support functions. (A, page 2-2, para B.1. and B.2.).

ALSO: The user community is divided into the following functional areas: research and development: test and evaluation; analysis and production and logistics. Specific applications for each of the functional areas are broken out below.

Education, training and operations. Re-creation of historical battles, doctrine and tactics development, command and unit training, operational planning and rehearsal, and wartime situation assessment.

Research and development. Requirements definition, engineering design support and systems performance assessment.

Test and evaluation. Early operational assessment, development and operational test design; and operational excursions and post-test analysis.

Analysis. Campaign analysis, force structure assessment, system configuration determination, sensitivity analysis and cost analysis.

Production and logistics. System producibility assessment, industrial base appraisal and logistics requirements determination. (B, page 2-2, para 2.1.).

19. ADVANCED DISTRIBUTED OPERATION (ADS). The ADS is an emerging form of simulation that has demonstrated the ability to link different types of simulators at dispersed locations; permitting the simulators and their crews to conduct operations on the same simulated battlefield environment. (B, page 4-13, para 4.5.4.).

20. M&S DIMENSIONS. Taken from Figure 2-1, page 2-3. This figure depicts a cube with three faces showing. On the front face is the Scope dimension consisting of four levels; Theater/Campaign, Mission/Battle, System/Engagement, and Subsystem/Component. On the side face is the Functional Area dimension consisting of five elements; ETMO, Analysis, R&D, T&E, and P&L. On the top face is the Sponsoring Component dimension consisting of six entities; Army, Navy, Air Force, Marine Corps, Combatant Commands, and Other. (A, page 2-3).

21. TYPE OF M&S. The three general types of models are: wargaming; training; and acquisition. Wargaming models range from single engagement (one-on-one) to joint theater level campaign operations. Training models range from single template instructional systems to complex virtual reality simulations. Acquisition models range from physical level phenomenon models through engineering component design tools to models of systems-in-the-end-use-environment. (B, page 1-3, para 1.3.).

22. SYSTEM ACQUISITION PROCESS. The DoDD 5000.1 establishes broad policies governing defense systems acquisition programs. It states that the three decision-making support systems must interact and interface with each other in order for the process to work effectively. The three systems illustrated in Figure 2-1 are: 1) requirements generation, 2) acquisition management and 3) planning, programming and budgeting system (PPBS). (B, page 2-3, para 2.2.).

23. AF HIERARCHY. The Air Force uses MS&A at five different levels:
(1) Strategic/National Military Strategy level
(2) Theater/ Campaign level
(3) Mission level
(4) Engagement/ Submission level
(5) System/ subsystem component (engineering) level (B, page 3-16, para 3.6.2.).

24. HIERARCHY. The levels within this hierarchy (Army) include:

Engineering: for design, cost, manufacturing and supportability. Provides measures of performance (MOP).

Engagement: for evaluating system effectiveness against enemy systems. Provides measures of effectiveness (MOE) at the system-on-system level.

Mission/Battle: effectiveness of a force package, or multiple platforms performing a specific mission. Provides MOE at the force-on -force level.

Theater/Campaign: outcomes of joint/combined forces in a theater/campaign level conflict, sometimes called measures of outcome (MOO). (B, page 4-6, para 4.4.).

25. STATIC. A static simulation model is a representation of a system at a particular time. (C, page 3).

26. DYNAMIC. A dynamic simulation model is a representation of a system as it evolves over time. (C, page 3).

27. DETERMINISTIC. A simulation model is said to be deterministic if it contains no random variables. (C, page 3).

28. STOCHASTIC. A simulation model is stochastic if it contains one or more random variables. (C, page 3).

29. DISCRETE. Discrete-event simulation concerns the modeling of a system as it evolves over time by a representation in which the state variables change only at a countable number of points in time. (C, page 4).

30. CONTINUOUS. Continuous simulation concerns the modeling over time of a system by a representation in which the state variables change continuously with respect to time. (C, page 46).

31. TYPES OF PLATFORMS. Main frames, personal computer, or workstations as some examples. (D).

32. LANGUAGE. FORTRAN, COBOL, Pascal, BASIC, etc. (D).

33. RUN TIME. How long it takes to run the simulation; minutes, hours, days, or weeks. (D).

34. ROLES OF AEROSPACE POWER. A potential discriminator of the various types of MS&A which could be useful for organization metrics. (D, also from AFM 1-1, Vol I).

35. JOINT M&S. Representations of joint and Service forces, capabilities, equipment, materiel, and services used in the joint environment or by two, or more, Military Services. (DoDD 5000.59). (A, page xiii).

36. WEAPON SYSTEM. Fighters, tankers, bombers, satellites, missiles, communications, intelligence, computers, etc. (D).

37. SYSTEM SEGMENT. An added discriminator for the "Weapon System" category. For instance, a user might be interested in fighter communication systems or fighter missiles. This field would include descriptors such as avionics, navigation, communications, weapons, missiles, AGE, maintenance support, cost, etc. (D).

38. LIMITATIONS. A text entry on describing limiting factors that affects the operation of the program. (D).

39. FREQUENCY OF USE. How often the item is used; daily, weekly, monthly, or yearly. (D).

40. OPR. The person to contact to obtain more information. It would include name, rank, and phone number at a minimum. (D).

41. DESCRIPTION. A text entry that describes the program and highlights any additional information that the OPR feels is important and not contained in other fields. (D).

42. DOMAIN. Air, land, sea, or any combination. (D).

APPENDIX C

SURVEY RESULTS CONCERNING USEFUL TRAITS

This appendix covers the results of the MS&A database survey. The spreadsheet, which follows, contains 21 columns. This page describes the information contained in each column.

Column 1, Item: This column is a numbering system.

Column 2, Potential Field: This column is the title of the potential field.

Column 3, Apply: This column breaks out three potential application areas for each potential field; namely does it apply to Models, Databases, or Analyses?

Column 4 - 16, 1 - 13: These columns provide the numerical responses of the survey participants.

Column 17, Total: This column yields the summed total across columns 4 - 16.

Column 18, #: This column shows the number of respondents who provide a numerical answer to each potential field.

Column 19, Avg: This column takes the Total and divides by the # (Column 17/Column 18) to yield an average result among the participants. Recall that this average must be 2.50 or less in order for the potential field to be considered for the database.

Column 20, Resp: This column shows the number of respondents to each potential field. This column differs from Column 18 by virtue that not all participants provided a numerical answer for the usefulness of a potential field. In those cases where a respondent identified an apply answer but no corresponding usefulness value, then the response was recorded as a alpha character and was not counted for the averaging purposes of Column 19.

Column 21, %: This column provides the percentage of the number of respondents who responded to each potential field. Recall that this percentage must exceed 50% in order for a potential field to be considered for the database.

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
1	Title (Ex: AF Acquisition Model)	M	1	1	1	1	1	1	1	1	1	1	1	1	1	13	13	1.00	13	1.00
		D	1	1	1	1	1	1	1	1	1	1	1	1	1	13	13	1.00	13	1.00
		A	1	1	1	1	1	1	1	1	1	1	1	1	1	13	13	1.00	13	1.00
2	Acronym (Ex: AFAM)	M	2	3	2	1	1	1	1	1	1	1	1	2	3	20	13	1.54	13	1.00
		D	-	3	2	-	1	1	1	1	1	1	1	2	3	17	11	1.55	11	0.85
		A	-	3	2	-	1	-	1	1	1	1	1	2	3	16	10	1.60	10	0.77
3	Common Use of M&S	M	2	4	5	1	2	1	2	1	4	3	2	2	1	30	13	2.31	13	1.00
		D	-	4	5	1	-	1	2	1	4	3	2	2	1	26	11	2.36	11	0.85
		A	-	4	5	1	2	-	2	1	4	-	2	2	1	24	10	2.40	10	0.77
4	Complex Data	M	5	-	-	-	-	3	-	5	4	-	1	-	1	19	6	3.17	6	0.46
		D	5	4	3	2	2	3	-	5	-	2	1	3	1	31	11	2.82	11	0.85
		A	5	-	-	2	-	-	-	5	-	2	-	3	1	18	6	3.00	6	0.46
5	Data V V & C	M	2	-	2	1	1	-	2	5	2	-	2	1	1	19	10	1.90	10	0.77
		D	2	1	2	1	1	2	2	5	2	3	2	1	-	24	12	2.00	12	0.92
		A	-	-	-	1	-	-	-	5	-	-	-	1	1	8	4	2.00	4	0.31
6	Class of Simulation	M	1	2	2	1	1	1	4	4	2	1	1	1	2	23	13	1.77	13	1.00
		D	-	-	2	1	-	-	-	4	-	-	1	1	-	9	5	1.80	5	0.38
		A	-	-	-	1	1	-	-	4	-	-	1	1	2	10	6	1.67	6	0.46
7	Data Quality consisting of:																			
7a	Source	M	-	-	-	-	-	-	M	-	1	-	1	-	-	2	2	1.00	3	0.23
		D	1	1	-	1	D	1	D	-	1	1	1	2	2	11	9	1.22	11	0.85
		A	1	-	-	-	-	-	A	-	1	-	-	-	2	4	3	1.33	4	0.31

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
7b	Accuracy	M	-	-	-	-	2	-	-	5	2	-	1	1	-	11	5	2.20	5	0.38
		D	-	-	2	1	2	1	-	5	2	2	1	1	2	19	10	1.90	10	0.77
		A	-	-	2	-	-	-	-	5	2	-	-	1	2	12	5	2.40	5	0.38
7c	Up-to-dateness	M	-	-	-	-	-	-	-	-	1	-	2	1	-	4	3	1.33	3	0.23
		D	-	1	2	1	D	1	-	-	1	2	2	1	2	13	9	1.44	10	0.77
		A	-	-	2	-	-	-	-	-	1	-	-	1	2	6	4	1.50	4	0.31
7d	Logical Consistency	M	-	-	-	-	-	-	-	4	4	-	2	-	-	10	3	3.33	3	0.23
		D	-	D	4	2	D	3	-	4	4	3	2	3	-	25	8	3.13	10	0.77
		A	-	-	4	-	-	-	-	4	4	-	-	3	-	15	4	3.75	4	0.31
7e	Completeness	M	-	-	-	-	-	-	-	4	5	-	1	-	-	10	3	3.33	3	0.23
		D	-	5	4	2	D	3	-	4	5	3	1	1	-	28	9	3.11	10	0.77
		A	-	-	4	-	-	-	-	4	-	-	-	1	-	9	3	3.00	3	0.23
7f	Clipping Indicator	M	-	-	5	-	-	-	-	-	3	-	-	-	-	8	2	4.00	2	0.15
		D	-	3	5	-	-	3	-	-	3	-	-	-	-	14	4	3.50	4	0.31
		A	-	-	5	-	-	-	-	-	3	-	-	-	-	8	2	4.00	2	0.15
7g	Security	M	1	-	2	2	1	-	1	-	2	1	1	-	-	11	8	1.38	8	0.62
		D	1	1	2	2	1	1	1	-	2	1	1	1	1	15	12	1.25	12	0.92
		A	1	-	2	-	1	-	1	-	2	1	-	1	1	10	8	1.25	8	0.62
7h	Releasability	M	1	-	1	2	1	-	1	1	2	2	1	1	-	13	10	1.30	10	0.77
		D	1	1	1	2	1	1	1	1	2	2	1	1	1	16	13	1.23	13	1.00
		A	1	-	1	2	1	-	1	1	2	-	-	1	1	11	9	1.22	9	0.69

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
8	Model V V & A	M	2	1	1	1	1	2	2	1	2	1	2	1	1	18	13	1.38	13	1.00
		D	-	-	-	-	-	-	-	1	-	-	2	-	-	3	2	1.50	2	0.15
		A	-	-	-	-	1	-	-	1	-	-	-	-	-	2	2	1.00	2	0.15
9	High Level Architecture Goals:																			
9a	Enitity Level Representation	M	-	5	5	2	3	2	-	-	4	3	-	-	4	28	8	3.50	8	0.62
		D	-	-	5	2	-	-	-	-	-	-	-	3	4	14	4	3.50	4	0.31
		A	-	-	5	-	3	-	-	-	-	3	-	3	4	18	5	3.60	5	0.38
9b	Interoperability	M	2	5	5	1	2	1	1	-	3	3	1	1	2	27	12	2.25	12	0.92
		D	2	-	5	1	2	-	1	-	3	3	1	-	2	20	9	2.22	9	0.69
		A	-	-	5	-	-	-	1	-	-	-	-	-	-	6	2	3.00	2	0.15
9c	Reuse	M	5	3	2	1	1	1	2	-	5	2	1	-	2	25	11	2.27	11	0.85
		D	5	-	2	1	1	-	2	-	5	2	1	1	2	22	10	2.20	10	0.77
		A	5	-	-	-	-	-	2	-	5	-	-	1	-	13	4	3.25	4	0.31
9d	Portability	M	3	5	1	1	2	1	3	-	2	2	1	1	-	22	11	2.00	11	0.85
		D	3	-	1	1	-	-	3	-	2	2	1	1	-	14	8	1.75	8	0.62
		A	3	-	-	-	-	-	3	-	2	-	-	-	-	8	3	2.67	3	0.23
9e	Distributive Operation	M	5	3	5	2	1	5	3	-	1	1	1	1	1	29	12	2.42	12	0.92
		D	5	-	5	-	-	-	3	-	-	-	1	1	1	16	6	2.67	6	0.46
		A	5	-	5	-	-	-	3	-	-	1	-	1	-	15	5	3.00	5	0.38
9f	Legacy Interface	M	5	2	1	2	1	1	2	-	4	1	1	1	-	21	11	1.91	11	0.85
		D	5	-	1	-	1	-	2	-	-	1	1	1	2	14	8	1.75	8	0.62
		A	5	-	-	-	-	-	2	-	-	1	-	1	-	9	4	2.25	4	0.31

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
9g	Scalability	M	5	4	2	2	2	1	3	4	3	2	2	1	2	33	13	2.54	13	1.00
		D	5	-	2	2	-	-	3	4	-	-	2	1	-	19	7	2.71	7	0.54
		A	5	-	-	-	-	-	-	4	3	-	-	1	-	13	4	3.25	4	0.31
9h	Technological Evolution	M	3	4	4	2	4	5	2	4	5	4	2	-	5	44	12	3.67	12	0.92
		D	3	-	4	2	-	-	2	4	5	-	2	-	5	27	8	3.38	8	0.62
		A	-	-	4	-	-	-	-	4	5	4	-	2	5	24	6	4.00	6	0.46
9i	COTS/GOTS Use	M	3	4	2	2	3	2	5	4	5	4	2	2	2	40	13	3.08	13	1.00
		D	-	-	2	-	-	-	-	4	5	4	2	-	-	17	5	3.40	5	0.38
		A	-	-	-	2	-	-	-	4	5	4	-	2	-	17	5	3.40	5	0.38
10	Aggregation Capable	M	3	4	-	2	2	4	1	5	-	1	3	-	3	28	10	2.80	10	0.77
		D	3	4	-	-	-	4	1	5	4	1	-	-	3	25	8	3.13	8	0.62
		A	3	4	-	2	-	-	-	5	-	-	-	2	3	19	6	3.17	6	0.46
11	Disaggregation Capable	M	3	3	-	2	2	4	2	5	-	1	3	-	3	28	10	2.80	10	0.77
		D	3	3	-	-	-	4	2	5	4	1	-	-	3	25	8	3.13	8	0.62
		A	3	3	-	2	-	-	-	5	-	-	-	-	3	16	5	3.20	5	0.38
12	Distributed Interactive Simulation	M	5	3	2	2	M	5	3	3	4	2	1	1	1	32	12	2.67	13	1.00
		D	5	3	2	2	-	-	-	3	-	2	1	1	1	20	9	2.22	9	0.69
		A	5	3	-	2	-	-	-	3	4	2	1	1	-	21	8	2.63	8	0.62
13	Fidelity	M	3	2	1	2	3	1	1	5	2	2	1	1	2	26	13	2.00	13	1.00
		D	-	2	1	2	-	-	1	5	2	-	-	1	2	16	8	2.00	8	0.62
		A	-	2	-	-	-	-	1	5	2	-	-	1	2	13	6	2.17	6	0.46

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
14	M & S Interoperability	M	5	2	-	1	4	1	1	2	2	2	2	2	2	26	12	2.17	12	0.92
		D	5	2	-	1	-	-	1	2	-	2	2	2	2	19	9	2.11	9	0.69
		A	5	2	-	-	-	-	1	2	-	-	-	2	-	12	5	2.40	5	0.38
15	Resolution	M	5	3	-	2	4	2	2	5	2	-	-	2	-	27	9	3.00	9	0.69
		D	5	3	-	2	-	2	2	5	-	-	-	2	-	21	7	3.00	7	0.54
		A	5	3	-	-	4	-	-	5	2	-	-	2	-	21	6	3.50	6	0.46
16	Military Capability	M	3	2	2	2	2	-	-	4	4	-	1	-	2	22	9	2.44	9	0.69
		D	-	-	2	2	-	-	3	4	-	-	1	-	-	12	5	2.40	5	0.38
		A	-	-	-	2	2	A	3	4	-	3	1	-	2	17	7	2.43	8	0.62
17	Scalability	M	5	M	-	2	3	1	3	-	2	-	-	-	-	16	6	2.67	7	0.54
		D	5	-	-	-	-	1	3	-	2	-	-	-	-	11	4	2.75	4	0.31
		A	5	-	-	2	-	-	-	-	2	-	-	-	-	9	3	3.00	3	0.23
18	Functional Area of Application	M	3	4	2	2	2	1	1	1	3	3	1	1	2	26	13	2.00	13	1.00
		D	-	-	2	-	-	-	1	1	3	3	1	1	-	12	7	1.71	7	0.54
		A	-	-	-	2	2	-	1	1	3	3	1	1	2	16	9	1.78	9	0.69
19	Distributed Operation	M	-	3	2	3	2	1	2	2	1	2	-	1	2	21	11	1.91	11	0.85
		D	-	-	2	3	-	-	2	2	1	2	-	1	-	13	7	1.86	7	0.54
		A	-	-	-	-	-	-	-	2	-	-	-	1	-	3	2	1.50	2	0.15
20	M & S Dimensions	M	1	4	5	2	2	1	5	5	1	1	-	-	5	32	11	2.91	11	0.85
		D	1	-	5	-	-	-	5	5	-	1	-	-	5	22	6	3.67	6	0.46
		A	1	-	5	2	-	-	5	5	-	1	-	-	5	24	7	3.43	7	0.54

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
21	Types of M & S	M	2	4	3	2	2	1	4	4	2	-	-	1	1	26	11	2.36	11	0.85
		D	-	-	3	-	-	-	-	4	-	-	-	1	-	8	3	2.67	3	0.23
		A	-	-	-	-	-	-	-	4	-	-	-	1	1	6	3	2.00	3	0.23
22	System Acquistion Process	M	2	4	5	2	2	1	5	4	4	3	-	5	2	39	12	3.25	12	0.92
		D	-	-	5	-	-	-	5	4	-	-	-	5	-	19	4	4.75	4	0.31
		A	-	-	5	-	-	-	5	4	4	3	-	5	2	28	7	4.00	7	0.54
23	AF Hierarchy	M	1	2	1	1	1	1	1	5	1	1	1	1	1	18	13	1.38	13	1.00
		D	-	-	1	-	-	-	-	5	1	-	1	1	-	9	5	1.80	5	0.38
		A	-	-	-	-	-	-	1	5	1	1	1	1	1	11	7	1.57	7	0.54
24	Hierarchy	M	1	2	5	1	1	1	1	5	1	2	1	5	1	27	13	2.08	13	1.00
		D	-	-	5	-	-	-	-	5	1	-	1	5	-	17	5	3.40	5	0.38
		A	-	-	5	-	-	-	1	5	1	2	1	5	1	21	8	2.63	8	0.62
25	Static	M	2	2	3	3	2	3	4	-	-	M	1	-	2	22	9	2.44	10	0.77
		D	-	-	-	-	-	-	-	-	3	-	1	-	-	4	2	2.00	2	0.15
		A	-	-	-	3	-	-	-	-	3	-	1	-	-	7	3	2.33	3	0.23
26	Dynamic	M	2	2	3	2	2	1	4	-	3	M	1	-	M	20	9	2.22	11	0.85
		D	-	-	-	-	-	-	-	-	3	-	1	-	-	4	2	2.00	2	0.15
		A	-	-	-	2	-	-	-	-	-	-	1	-	-	3	2	1.50	2	0.15
27	Deterministic	M	2	2	3	3	2	1	4	-	5	2	1	-	M	25	10	2.50	11	0.85
		D	-	-	-	-	-	1	-	-	5	-	1	-	-	7	3	2.33	3	0.23
		A	-	-	-	3	-	-	-	-	5	-	1	-	-	9	3	3.00	3	0.23

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
28	Stochastic	M	2	2	3	3	2	1	4	-	5	2	1	-	M	25	10	2.50	11	0.85
		D	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	1.00	1	0.08
		A	-	-	-	3	-	-	-	-	-	-	1	-	-	4	2	2.00	2	0.15
29	Discrete	M	2	4	3	3	2	1	4	-	3	2	1	-	M	25	10	2.50	11	0.85
		D	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	1.00	1	0.08
		A	-	-	-	3	-	-	-	-	-	-	1	-	-	4	2	2.00	2	0.15
30	Continuous	M	2	4	3	3	2	1	4	-	3	2	1	-	M	25	10	2.50	11	0.85
		D	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	1.00	1	0.08
		A	-	-	-	3	-	-	-	-	-	-	1	-	-	4	2	2.00	2	0.15
31	Types of Platform	M	1	1	1	2	2	1	2	-	5	3	1	1	1	21	12	1.75	12	0.92
		D	1	-	1	2	-	-	-	-	5	3	1	1	-	14	7	2.00	7	0.54
		A	1	-	-	2	2	-	-	-	5	-	-	1	-	11	5	2.20	5	0.38
32	Language	M	2	1	2	2	1	1	1	1	1	1	1	1	1	16	13	1.23	13	1.00
		D	-	-	-	2	-	-	-	1	1	-	-	1	-	5	4	1.25	4	0.31
		A	-	-	-	-	-	-	-	1	-	-	-	-	-	1	1	1.00	1	0.08
33	Run Time	M	2	5	2	2	4	1	1	-	3	2	2	-	1	25	11	2.27	11	0.85
		D	-	-	-	-	4	-	-	-	-	2	-	-	-	6	2	3.00	2	0.15
		A	-	-	-	-	4	-	-	-	-	-	-	1	-	5	2	2.50	2	0.15
34	Roles of Aerospace Power	M	3	5	2	2	3	1	2	5	2	-	5	2	2	34	12	2.83	12	0.92
		D	-	-	-	-	-	-	-	5	-	-	5	-	-	10	2	5.00	2	0.15
		A	-	-	-	-	3	-	-	5	2	3	5	2	2	22	7	3.14	7	0.54

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
35	Joint M & S	M	5	2	5	2	2	1	2	5	4	2	-	1	2	33	12	2.75	12	0.92
		D	5	-	5	2	-	-	2	5	4	2	-	1	2	28	9	3.11	9	0.69
		A	5	-	5	-	2	-	2	5	4	-	-	1	2	26	8	3.25	8	0.62
36	Weapon System	M	2	3	4	2	2	1	1	5	2	2	-	-	1	25	11	2.27	11	0.85
		D	-	-	4	2	-	1	1	5	-	2	-	-	-	15	6	2.50	6	0.46
		A	-	-	-	-	-	-	1	5	2	-	-	-	-	8	3	2.67	3	0.23
37	System segment	M	2	2	2	1	2	1	3	5	2	3	-	5	2	30	12	2.50	12	0.92
		D	-	-	2	1	-	1	3	5	-	3	-	5	-	20	7	2.86	7	0.54
		A	-	-	-	1	-	-	-	5	2	-	-	5	-	13	4	3.25	4	0.31
38	Limitations	M	1	1	2	2	1	1	1	1	3	1	1	1	1	17	13	1.31	13	1.00
		D	1	1	-	-	1	1	1	1	-	1	1	1	1	10	10	1.00	10	0.77
		A	1	1	-	-	1	1	1	1	3	1	1	1	1	13	11	1.18	11	0.85
39	Frequency of Use	M	5	4	4	2	2	2	2	5	5	3	3	5	2	44	13	3.38	13	1.00
		D	5	4	4	-	-	-	2	5	-	3	3	5	-	31	8	3.88	8	0.62
		A	5	4	-	-	-	-	-	5	-	3	3	5	2	27	7	3.86	7	0.54
40	OPR	M	1	1	1	1	1	1	1	1	1	2	1	1	2	15	13	1.15	13	1.00
		D	1	1	1	1	1	1	1	1	1	2	1	1	2	15	13	1.15	13	1.00
		A	1	1	1	-	1	-	1	1	1	2	1	1	2	13	11	1.18	11	0.85
41	Description	M	1	2	1	1	1	1	1	1	1	1	1	1	1	14	13	1.08	13	1.00
		D	1	2	1	1	1	1	1	1	1	1	1	1	1	14	13	1.08	13	1.00
		A	1	2	1	1	1	1	1	1	1	1	1	1	1	14	13	1.08	13	1.00

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG	RESP	%
42	Domain	M	4	4	5	2	2	1	1	3	4	4	3	5	-	38	12	3.17	12	0.92
		D	4	4	5	-	-	1	1	3	-	4	3	5	-	30	9	3.33	9	0.69
		A	4	4	5	2	2	1	1	3	4	4	3	5	-	38	12	3.17	12	0.92

NOTE 1: If no entry is made in both the "apply to" and "usefulness" columns for a potential field, a dash is recorded and equates to a value of zero.

NOTE 2: If an entry is recorded in only one or two of the three possible entries in the "apply to" column and an entry is circled in the "usefulness" column, then the "usefulness" value is recorded for the circled "apply to" entries and a dash is recorded elsewhere.

NOTE 3: If an "apply to" entry was made on the survey, but no "usefulness" number was circled, then the letter of the "apply to" entry is recorded.

NOTE 4: If a "usefulness" entry was made but no "apply to" entry was made, then the "usefulness" value was recorded for all three "apply to" options.

APPENDIX D

SURVEY RESULTS CONCERNING MUTUAL EXCLUSIVENESS

This appendix covers the results of the MS&A database survey. The spreadsheet, which follows, contains 19 columns. This page describes the information contained in each column.

Column 1, Item: This column is a numbering system.

Column 2, Potential Field: This column is the title of the potential field.

Column 3, Apply: This column breaks out an affirmative or negative answer concerning mutual exclusiveness for each potential field.

Column 4 - 16, 1 - 13: These columns provide the responses of the survey participants. The number one is entered in the appropriate row (yes or no) for each potential field to reflect an answer.

Column 17, Total: This column yields the summed total across columns 4 - 16.

Column 18, #: This column shows the number of respondents who provide a answer to each potential field.

Column 19, Avg: This column takes the Total and divides by the # (Column 17/Column 18) to yield an average result among the participants. Recall that this average must be greater than 50% in order for the potential field to be considered mutually exclusive.

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG
1	Title (Ex: AF Acquisition Model)	Yes	1	-	-	1	-	-	-	1	1	-	-	-	1	5	12	0.42
		No	-	-	1	-	1	1	1	-	-	1	1	1	-	7	12	0.58
2	Acronym (Ex: AFAM)	Yes	-	-	-	1	-	-	-	1	-	-	1	-	1	4	12	0.33
		No	1	-	1	-	1	1	1	-	1	1	-	1	-	8	12	0.67
3	Common Use of M&S	Yes	-	-	-	-	-	-	-	-	1	1	-	-	-	2	10	0.20
		No	1	-	1	1	1	1	-	1	-	-	1	1	-	8	10	0.80
4	Complex Data	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	9	0.00
		No	-	-	1	1	1	1	-	-	1	1	1	1	1	9	9	1.00
5	Data V V & C	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	11	0.00
		No	1	1	1	1	1	1	-	-	1	1	1	1	1	11	11	1.00
6	Class of Simulation	Yes	-	-	-	-	1	-	-	-	-	1	-	-	-	2	10	0.20
		No	1	-	1	1	-	1	-	-	1	-	1	1	1	8	10	0.80
7	Data Quality consisting of:																	
7a	Source	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	9	0.00
		No	1	-	-	1	1	1	-	-	1	1	1	1	1	9	9	1.00
7b	Accuracy	Yes	-	-	-	-	-	1	-	-	-	1	-	-	-	2	9	0.22
		No	-	-	1	1	1	-	-	-	1	-	1	1	1	7	9	0.78
7c	Up-to-dateness	Yes	-	-	-	-	-	1	-	-	-	1	-	-	-	2	9	0.22
		No	-	-	1	1	1	-	-	-	1	-	1	1	1	7	9	0.78
7d	Logical Consistency	Yes	-	-	-	-	-	1	-	-	-	-	-	-	-	1	8	0.13
		No	-	-	1	1	1	-	-	-	1	1	1	1	-	7	8	0.88

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG
7e	Completeness	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	8	0.00
		No	-	-	1	1	1	1	-	-	1	1	1	1	-	8	8	1.00
7f	Clipping Indicator	Yes	-	-	-	-	-	1	-	-	-	-	-	-	-	1	3	0.33
		No	-	-	1	-	-	-	-	-	1	-	-	-	-	2	3	0.67
7g	Security	Yes	-	-	-	1	1	-	-	-	-	-	-	-	-	2	10	0.20
		No	1	-	1	-	-	1	-	-	1	1	1	1	1	8	10	0.80
7h	Releasability	Yes	-	-	-	-	1	-	-	1	-	-	-	-	-	2	11	0.18
		No	1	-	1	1	-	1	-	-	1	1	1	1	1	9	11	0.82
8	Model V V & A	Yes	-	-	-	-	-	-	-	1	-	-	-	-	-	1	10	0.10
		No	-	-	1	1	1	1	-	-	1	1	1	1	1	9	10	0.90
9	High Level Architecture Goals:																	
9a	Enitity Level Representation	Yes	-	-	-	-	-	-	-	-	1	1	-	-	-	2	7	0.29
		No	-	-	1	1	1	1	-	-	-	-	-	1	-	5	7	0.71
9b	Interoperability	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	10	0.00
		No	1	-	1	1	1	1	-	-	1	1	1	1	1	10	10	1.00
9c	Reuse	Yes	-	-	-	-	1	-	-	-	-	-	-	-	-	1	7	0.14
		No	-	-	1	1	-	1	-	-	-	1	1	-	1	6	7	0.86
9d	Portability	Yes	-	-	-	-	-	-	-	-	1	-	-	-	-	1	8	0.13
		No	-	-	1	1	1	1	-	-	-	1	1	1	-	7	8	0.88
9e	Distributive Operation	Yes	-	-	-	-	1	-	-	-	1	-	-	-	-	2	8	0.25
		No	-	-	1	1	-	1	-	-	-	1	1	-	1	6	8	0.75

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG
9f	Legacy Interface	Yes	-	-	-	-	1	-	-	-	-	1	-	-	-	2	8	0.25
		No	-	-	1	1	-	1	-	-	1	-	1	-	1	6	8	0.75
9g	Scalability	Yes	-	-	-	-	1	-	-	-	1	1	-	-	-	3	9	0.33
		No	-	-	1	1	-	1	-	-	-	-	1	1	1	6	9	0.67
9h	Technological Evolution	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	9	0.00
		No	1	-	1	1	1	1	-	-	1	1	1	1	-	9	9	1.00
9i	COTS/GOTS Use	Yes	-	-	-	-	1	-	-	-	1	-	-	-	-	2	9	0.22
		No	1	-	1	1	-	1	-	-	-	1	1	-	1	7	9	0.78
10	Aggregation Capable	Yes	-	-	-	-	1	-	-	-	1	-	-	-	-	2	7	0.29
		No	-	-	-	1	-	1	-	-	-	1	1	-	1	5	7	0.71
11	Disaggregation Capable	Yes	-	-	-	-	1	-	-	-	1	-	-	-	-	2	7	0.29
		No	-	-	-	1	-	1	-	-	-	1	1	-	1	5	7	0.71
12	Distributed Interactive Simulation	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	1	7	0.14
		No	-	-	-	1	1	-	-	-	1	-	1	1	1	6	7	0.86
13	Fidelity	Yes	-	-	-	-	-	-	-	-	1	-	-	-	-	1	8	0.13
		No	1	-	-	1	1	1	-	-	-	1	1	-	1	7	8	0.88
14	M & S Interoperability	Yes	-	-	-	-	1	-	-	-	1	-	-	-	-	2	7	0.29
		No	-	-	-	1	-	1	-	-	-	1	1	-	1	5	7	0.71
15	Resolution	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	1	5	0.20
		No	-	-	-	1	1	1	-	-	1	-	-	-	-	4	5	0.80

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG
16	Military Capability	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	8	0.00
		No	1	-	-	1	1	1	-	-	1	1	1	-	1	8	8	1.00
17	Scalability	Yes	-	-	-	-	-	-	-	-	1	-	-	-	-	1	4	0.25
		No	-	-	-	1	1	1	-	-	-	-	-	-	-	3	4	0.75
18	Functional Area of Application	Yes	-	-	-	1	-	-	-	-	-	-	-	-	-	1	10	0.10
		No	-	-	1	-	1	1	-	1	1	1	1	1	1	9	10	0.90
19	Distributed Operation	Yes	-	-	-	-	-	-	-	1	1	-	-	-	-	2	8	0.25
		No	-	-	1	1	1	1	-	-	-	1	-	-	1	6	8	0.75
20	M & S Dimensions	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	1	7	0.14
		No	1	-	1	1	1	1	-	-	1	-	-	-	-	6	7	0.86
21	Types of M & S	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	7	0.00
		No	1	-	1	1	1	1	-	-	1	-	-	-	1	7	7	1.00
22	System Acquistion Process	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	7	0.00
		No	1	-	-	1	1	1	-	-	1	1	-	-	1	7	7	1.00
23	AF Hierarchy	Yes	-	-	-	-	-	1	-	-	-	1	-	-	-	2	10	0.20
		No	1	-	1	1	1	-	-	-	1	-	1	1	1	8	10	0.80
24	Hierarchy	Yes	-	-	-	-	-	1	-	-	-	1	-	-	-	2	8	0.25
		No	1	-	-	1	1	-	-	-	1	-	1	-	1	6	8	0.75
25	Static	Yes	-	-	-	-	1	1	-	-	1	-	-	-	-	3	8	0.38
		No	1	-	1	1	-	-	-	-	-	-	1	-	1	5	8	0.63

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG
26	Dynamic	Yes	-	-	-	-	1	1	-	-	1	-	-	-	-	3	8	0.38
		No	1	-	1	1	-	-	-	-	-	-	1	-	1	5	8	0.63
27	Deterministic	Yes	-	-	-	-	1	1	-	-	1	1	-	-	-	4	9	0.44
		No	1	-	1	1	-	-	-	-	-	-	1	-	1	5	9	0.56
28	Stochastic	Yes	-	-	-	-	1	1	-	-	1	1	-	-	-	4	9	0.44
		No	1	-	1	1	-	-	-	-	-	-	1	-	1	5	9	0.56
29	Discrete	Yes	-	-	-	-	1	1	-	-	1	1	-	-	-	4	9	0.44
		No	1	-	1	1	-	-	-	-	-	-	1	-	1	5	9	0.56
30	Continuous	Yes	-	-	-	-	1	1	-	-	1	1	-	-	-	4	9	0.44
		No	1	-	1	1	-	-	-	-	-	-	1	-	1	5	9	0.56
31	Types of Platform	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	7	0.00
		No	1	-	-	1	-	1	-	-	1	1	1	-	1	7	7	1.00
32	Language	Yes	-	-	-	1	-	-	-	-	1	1	-	-	-	3	10	0.30
		No	1	-	1	-	1	1	-	1	-	-	1	-	1	7	10	0.70
33	Run Time	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	9	0.00
		No	1	-	1	1	1	1	-	-	1	1	1	-	1	9	9	1.00
34	Roles of Aerospace	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	8	0.00
		No	1	-	1	1	1	1	-	-	1	1	-	-	1	8	8	1.00
35	Joint M & S	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	8	0.00
		No	-	-	1	1	1	1	-	-	1	1	1	-	1	8	8	1.00

ITEM	POTENTIAL FIELD	APPLY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL	#	AVG
36	Weapon System	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	1	8	0.13
		No	1	-	1	1	1	1	-	-	1	-	-	-	1	7	8	0.88
37	System segment	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	1	7	0.14
		No	-	-	1	1	1	1	-	-	1	-	-	-	1	6	7	0.86
38	Limitations	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	7	0.00
		No	-	-	-	1	1	1	-	-	1	1	1	-	1	7	7	1.00
39	Frequency of Use	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	8	0.00
		No	-	-	1	1	1	1	-	-	1	1	1	-	1	8	8	1.00
40	OPR	Yes	-	-	-	1	-	-	-	1	-	1	-	-	-	3	8	0.38
		No	-	-	1	-	1	1	-	-	1	-	1	-	-	5	8	0.63
41	Description	Yes	-	-	-	1	-	-	-	1	-	1	-	-	-	3	9	0.33
		No	-	-	1	-	1	1	-	-	1	-	1	-	1	6	9	0.67
42	Domain	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	0	6	0.00
		No	-	-	-	1	1	1	-	-	1	1	1	-	-	6	6	1.00

NOTE 1: If no entry was made in the "exclusive?" column for a potential field, a dash is recorded and equates to a value of zero.

APPENDIX E

DATA DICTIONARY

This data dictionary contains the definition of the fields that comprise the MS&A prototype database. There are four tables which make up this database:

- Models
- Databases
- Analyses
- Office

Of the four identified tables, only two have been developed for the prototype; Models and Office. Below is the definition of each field contained in the prototype. The table, to which each field belongs, makes up a portion of the title for that field. For instance, the field entitled Model_Acronym is associated with the Models table. Each entry contains the name of the field and associated definition, the name of the field as used in the database, length of the field, type of data that is entered into the field, and any notes concerning the field for the Models and Office tables.

ACRONYM: This field is the acronym associated with the title of the MS&A tool, if any.

NAME:	MODEL_ACRONYM
LENGTH:	20
TYPE:	Text
NOTES:	This field, in conjunction with MODEL_TITLE and MODEL_VERSION_NUMBER, makes up the primary key for the Models table.

ADDRESS: This field is the address of the office or unit responsible for maintaining the MS&A tool.

NAME:	OPR_ADDRESS
LENGTH:	200

TYPE: Text

AF HIERARCHY: This field uses the five levels of the Air Force Hierarchy as a selective criteria. The five levels of the AF Hierarchy are "(1) Strategic/National Military Strategy level, (2) Theater/ Campaign level, (3) Mission level, (4) Engagement/ Submission level, and (5) System/ subsystem component (engineering) level." (17: 3-16) There are five fields which contribute to the AF Hierarchy as follows:

NAME: MODEL_AF_HIER_STRATEGY
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_AF_HIER_THEATER
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_AF_HIER_MISSON
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_AF_HIER_ENGAGE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_AF_HIER_SYSTEM
LENGTH: 1
TYPE: Yes/No

CLASS OF SIMULATION: This field is the categorization of simulation into live, virtual- human, virtual-prototype, and constructive designations. Live simulation involves real people operating real systems. Virtual-human means a virtual simulation with a human-in-the-loop aspect. Other names include man-in-the-loop, warfighter-in- the-loop, or person-in-the-loop. Virtual-prototype is the interface of a realistic computer simulation within a synthetic environment. Constructive simulation is simulations that involve simulated people operating simulated systems. There are four fields which contribute to the Class of Simulation as follows:

NAME: MODEL_CLASS_LIVE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_CLASS_VIRTUAL_HUMAN

LENGTH: 1
TYPE: Yes/No

NAME: MODEL_CLASS_VIRTUAL_PROTO
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_CLASS_CONSTRUCTIVE
LENGTH: 1
TYPE: Yes/No

COMMERCIAL PHONE: This field is the commercial phone number of the office or unit responsible for maintaining the MS&A tool.

NAME: OPR_COMMPHONE
LENGTH: 15
TYPE: Text

COMMON-USE M&S: This field describes the M&S applications, services, or materials that can apply or be provided by a DoD Component to two or more DoD Components.

NAME: MODEL_COMMON
LENGTH: Up To 64,000
TYPE: Memo

DATA VERIFICATION, VALIDATION, & CERTIFICATION (VV&C). These fields represent the Data VV&C status of the data that went into developing the model. Data VV&C is "the process of verifying the internal consistency and correctness of data, validating that it represents real world entities appropriate for its intended purpose or an expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses." (27: x) There are two fields which contribute to the Data VV&C status as follows:

NAME: MODEL_DATA_VVC_CODE
LENGTH: 2
TYPE: Text
NOTES: Must enter either "Ve" for verification, "Va" for validation, or "Ce" for certification.

NAME: MODEL_DATA_VVC_DATE

LENGTH: 8
TYPE: Date/Time

DESCRIPTION: This field is a text entry that describes the program and highlights any additional information that the OPR feels is important and not contained in other fields.

NAME: MODEL_DESCRIP
LENGTH: Up to 64,000
TYPE: Memo

DISTRIBUTED OPERATION: This field is a text entry that describes how the "operation of the simulation can be spread across several platforms, if need be, particularly to collocate simulation assets with geographically dispersed users." (27: A-2)

NAME: MODEL_DISTRIBUTED_OPS
LENGTH: Up to 64,000
TYPE: Memo

DUTY ORGANIZATION: This field is the name of the duty organization responsible for maintaining the MS&A tool. This field is found in both the Models and Office tables.

NAME: MODEL_DUTYORG
LENGTH: 75
TYPE: Text
NOTES: This field, in conjunction with MODEL_OFFICE_SYMBOL, makes up the foriegn key for the Models table.

NAME: OPR_DUTYORG
LENGTH: 75
TYPE: Text
NOTES: This field, in conjunction with OPR_OFFICE_SYMBOL, makes up the primary key for the Office table.

DUTY PHONE: This field is the phone number of the office or unit responsible for maintaining the MS&A tool.

NAME: OPR_DUTYPHONE
LENGTH: 15

TYPE: Text

EMAIL ADDRESS: This field is the E-mail address of the office or unit responsible for maintaining the MS&A tool.

NAME: OPR_EMAIL
LENGTH: 50
TYPE: Text

EXTENSION: This field provides an extension or multiple extension capability for the phone number of the office or unit responsible for maintaining the MS&A tool.

NAME: OPR_EXTENSION
LENGTH: 25
TYPE: Text

FAX, COMMERCIAL: This field is the commercial fax number of the office or unit responsible for maintaining the MS&A tool.

NAME: OPR_FAXCOMM
LENGTH: 15
TYPE: Text

FAX, DSN: This field is the DSN fax number of the office or unit responsible for maintaining the MS&A tool.

NAME: OPR_FAXDSN
LENGTH: 15
TYPE: Text

FIDELITY: This field describes "the accuracy of the representation when compared to the real-world." (27: xii)

NAME: MODEL_FIDELITY
LENGTH: Up to 64,000
TYPE: Memo

FUNCTIONAL AREA OF APPLICATION: This field represents the division of the user community into the following functional areas; education, training, military

operations, research and development, test and evaluation, analysis, production, and logistics. Education, training, and military operations is concerned with the re-creation of historical battles, doctrine and tactics development, command and unit training, operational planning and rehearsal, and wartime situation assessment. Research and development looks at requirements definition, engineering design support and systems performance assessment. Test and evaluation is the early operational assessment, development and operational test design; and operational excursions and post-test analysis. Analysis focuses on campaign analysis, force structure assessment, system configuration determination, sensitivity analysis and cost analysis. Production, logistics, and design is concerned with system producibility assessment, industrial base appraisal, and logistics requirements determination. There are nine fields which contribute to Functional Area of Application as follows:

NAME: MODEL_FUNC_AREA_EDUC
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_TRAIN
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_MIL_OPS
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_ANAL
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_R&D
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_T&E
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_PROD
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_LOG
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_FUNC_AREA_DESIGN
LENGTH: 1
TYPE: Yes/No

INTERNAL CHARACTERISTICS: This field is based upon certain characteristics that could describe the internal operation or method of computation within a simulation model. There are six characteristics; Static, Dynamic, Deterministic, Stochastic, Discrete, and Continuous. A static simulation model is a representation of a system at a particular time, whereas a dynamic simulation model is a representation of a system as it evolves over time. (11: 3) A simulation model is said to be deterministic if it contains no random variables and it is considered to be stochastic if it contains one or more random variables. (11: 3) Discrete-event simulation concerns the modeling of a system as it evolves over time by a representation in which the state variables change only at a countable number of points in time. (11: 4) Continuous simulation concerns the modeling over time of a system by a representation in which the state variables change continuously with respect to time. (11: 46) There are six fields which contribute to Internal Characteristics as follows:

NAME: MODEL_STATIC
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_DYNAMIC
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_DETERMIN
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_STOCHASTIC
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_DISCRETE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_CONTINUOUS
LENGTH: 1
TYPE: Yes/No

LANGUAGE: This field describes the language the model is written in and any special input criteria.

NAME:	MODEL_LANGUAGE
LENGTH:	Up to 64,000
TYPE:	Memo

LEGACY INTERFACE: This is a yes/no field that reflects whether or not a "new simulations will interoperate with some selected set of existing simulations." (27: A-2)

NAME:	MODEL_LEGACY
LENGTH:	1
TYPE:	Yes/No

LIMITATIONS: This field is a text entry on describing the limiting factors that affects the operation of the program.

NAME:	MODEL_LIMITS
LENGTH:	Up to 64,000
TYPE:	Memo

M&S INTEROPERABILITY: This field is a text entry that defines "the ability of a model or simulation to provide services to, and accept services from, other models and simulations, and to use the services so exchanged to enable them to operate effectively together." (27: xv)

NAME:	MODEL_M&S_INTEROP
LENGTH:	Up to 64,000
TYPE:	Memo

MILITARY CAPABILITY. This field is a selection criteria based on the Four Pillars of Military Capability. it is suggested that M&S can substantially improve capability and decision making in each of the four pillars of military capability: (1) readiness, (2) modernization, (3) force structure, and (4) substainability. There are four fields which contribute to Military Capability as follows:

NAME:	MODEL_MILCAP_READINESS

LENGTH: 1
TYPE: Yes/No

NAME: MODEL_MILCAP_MODERN
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_MILCAP_FORCE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_MILCAP_SUSTAIN
LENGTH: 1
TYPE: Yes/No

MODEL VERIFICATION, VALIDATION, AND ACCREDITATION (VV&A): This field displays the Verification, Validation, and/or Accreditation of a model. Accreditation is "the official certification that a model or simulation is acceptable for use for a specific purpose." (27: viii) Validation is "the process of determining the extent to which a model or simulation is an accurate representation of the real world from the perspective of the intended use(s) of the model or simulation." (27: xvi) Verification is "the process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques." (27: xvii) There are six fields which describe the Model Verification, Validation, and Accreditation as follows:

NAME: MODEL_VER_DATE
LENGTH: 8
TYPE: Date/Time

NAME: MODEL_VER_AGENCY
LENGTH: 55
TYPE: Text

NAME: MODEL_VAL_DATE
LENGTH: 8
TYPE: Date/Time

NAME: MODEL_VAL_AGENCY
LENGTH: 55
TYPE: Text

NAME: MODEL_ACCRED_DATE
LENGTH: 8
TYPE: Date/Time

NAME: MODEL_ACCRED_AGENCY
LENGTH: 55
TYPE: Text

OFFICE SYMBOL: This field is the office symbol of the unit responsible for maintaining the MS&A tool. This field is found in both the Models and Office tables.

NAME: MODEL_OFFICE_SYMBOL
LENGTH: 10
TYPE: Text
NOTES: This field, in conjunction with MODEL_DUTYORG, makes up the foriegn key for the Models table.

NAME: OPR_OFFICE_SYMBOL
LENGTH: 10
TYPE: Text
NOTES: This field, in conjunction with OPR_DUTYORG, makes up the primary key for the Office table.

PORTABILITY: This field is a text entry which discusses how a "simulation can be run on a variety of computing platforms." (27: A-2)

NAME: MODEL_PORTABILITY
LENGTH: Up to 64,000
TYPE: Memo

REMARKS: This field provides the OPR the capability of adding remarks such as names or other pieces of important information.

NAME: OPR_REMARKS
LENGTH: 250
TYPE: Text

REUSE: This field is a text entry that describes which "components of one simulation can be used in another appropriate simulation." (27: A-2)

NAME: MODEL_REUSE
LENGTH: Up to 64,000
TYPE: Memo

ROLES OF AEROSPACE POWER: This field is a potential discriminator of the various types of MS&A which could be useful for organization metrics. There are four roles of aerospace power; Aerospace Control, Force Application, Force Enhancement, and Force Support. There are four fields which describe Roles of Aerospace Power:

NAME: MODEL_ROLES_CONTROL
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_ROLES_APPL
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_ROLES_ENHANCE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_ROLES_SUPPORT
LENGTH: 1
TYPE: Yes/No

RUN TIME: This field describes how long it takes to run the simulation; i.e. minutes, hours, days, or weeks.

NAME: MODEL_RUN_TIME
LENGTH: Up to 64,000
TYPE: Memo

SECURITY LEVEL: This field identifies the Security level of the model.

NAME: MODEL_SECURITY_LEVEL
LENGTH: 2
TYPE: Text
NOTES: Must enter either "Un" for unclassified, "CN" for confidential, "SE" for secret, "TS" for top secret, "FO" is for official use only, "NO" for no foreign nationals,

"LD" for limited distribution, and "SI" for secret compartmented information.

STANDALONE: This field shows whether or not the MS&A tool can stand alone or can only provide data when incorporated with another model.

NAME:	MODEL_STANDALONE
LENGTH:	1
TYPE:	Yes/No

SYSTEM SEGMENT. This field is an added discriminator for the "Weapon System" category. For instance, a user might be interested in fighter communication systems or fighter missiles. This field would include descriptors such as avionics, navigation, radar, communications, weapons, missiles, intelligence, computers, cost, propulsion, structure, and other. Conversely, this field could be used as a selection criteria in its own as well. There are twelve fields contained in System Segment as follows:

NAME:	MODEL_SYSTEM_AVIONIC
LENGTH:	1
TYPE:	Yes/No
NAME:	MODEL_SYSTEM_NAV
LENGTH:	1
TYPE:	Yes/No
NAME:	MODEL_SYSTEM_RADAR
LENGTH:	1
TYPE:	Yes/No
NAME:	MODEL_SYSTEM_COMM
LENGTH:	1
TYPE:	Yes/No
NAME:	MODEL_SYSTEM_WEAPON
LENGTH:	1
TYPE:	Yes/No
NAME:	MODEL_SYSTEM_MISSILE
LENGTH:	1
TYPE:	Yes/No
NAME:	MODEL_SYSTEM_INTEL

LENGTH: 1
TYPE: Yes/No

NAME: MODEL_SYSTEM_COMPUTER
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_SYSTEM_COST
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_SYSTEM_PROPULSION
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_SYSTEM_STRUCTURE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_SYSTEM_OTHER
LENGTH: 1
TYPE: Yes/No

TITLE: This field is the title of the MS&A tool.

NAME: MODEL_TITLE
LENGTH: 100
TYPE: Text
NOTES: This field, in conjunction with MODEL_ACRONYM and MODEL_VERSION_NUMBER, makes up the primary key for the Models table.

TYPE OF M&S: This field is a selective one based on the "three general types of models which are; wargaming, training, and acquisition. Wargaming models range from single engagement (one-on-one) to joint theater level campaign operations. Training models range from single template instructional systems to complex virtual reality simulations. Acquisition models range from physical level phenomenon models through engineering component design tools to models of systems-in-the-end-use-environment." (17: 1-3) There are three fields which contribute to Types of M&S as follows:

NAME: MODEL_TYPE_WARGAME
LENGTH: 1

TYPE: Yes/No

NAME: MODEL_TYPE_TRAIN
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_TYPE_ACQ
LENGTH: 1
TYPE: Yes/No

TYPES OF PLATFORMS: This field describes the type of platform or hardware requirements needed to run the model. Main frames, personal computer, or workstations as some examples.

NAME: MODEL_PLATFORM
LENGTH: Up to 64,000
TYPE: Memo

VERSION NUMBER: This field is the version number of the MS&A tool.

NAME: MODEL_VERSION_NUMBER
LENGTH: 8
TYPE: Number (Double)
NOTES: This field, in conjunction with MODEL_ACRONYM and MODEL_TITLE, makes up the primary key for the Models table.

WEAPON SYSTEM: This field is a high level descriptor of the entity that the model is capable of depicting. Entities identified are fighters, tankers, transports, bombers, helicopters, satellites, missiles, command and control, and others. There are nine fields which describe Weapon System as follows:

NAME: MODEL_WEAPON_FIGHTER
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_WEAPON_TANKER
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_WEAPON_TRANSPORT
LENGTH: 1

TYPE: Yes/No

NAME: MODEL_WEAPON_BOMBER
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_WEAPON_HELI
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_WEAPON_SATELITE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_WEAPON_MISSILE
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_WEAPON_COMAND
LENGTH: 1
TYPE: Yes/No

NAME: MODEL_WEAPON_OTHER
LENGTH: 1
TYPE: Yes/No

APPENDIX F

QUESTIONNAIRE

This questionnaire is designed to solicit your inputs on the MS&A Prototype Database. Your responses are purely voluntary and greatly appreciated.

What is your AFSC or Civilian Code? ______________________________

What is your rank or grade? ______________________________

How long have you been associated with M&S? ______________________________

Please think back to your last M&S experience and the circumstances or requirements associated with that experience.

What was the title of the M&S model or tool that you used? ____________________

____

Now based on that experience, try using the database to ascertain what models or tools that are available to address your area of application.

Question 1: Did your model or tool appear in the suggested list? **YES** **NO**

Question 2: For each of the suggested models or tools, please apply a usefulness rating as to whether or not that particular model or tool would be useful in your application. The usefulness ratings are as follows:

1 = Extremely Useful

3 = Marginally Useful

5 = Not Useful At All

MODEL TITLE	USEFULNESS
______________________________	**1 2 3 4 5**
______________________________	**1 2 3 4 5**

MODEL TITLE	USEFULNESS				
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5

Question 3: How would rate the usefulness of this database (using the same scale)?

1 2 3 4 5

Thank you for your assistance. If you should have any comments or suggestions, please feel free to use the space below.

Bibliography

1. Arnold, Lt Col Chris, Class Notes, IMGT 699-61, Introduction to Database Systems. Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, Wright-Patterson AFB OH, Fall Quarter 1994.

2. Bell, David and Jane Grimson. Distributed Database Systems. Reading MA: Addison-Wesley Publishing Company, 1992.

3. Chimelski, Maj Steve, HQ AFMC/XRX, Wright-Patterson AFB OH. Personal interview. 26 Jul 94.

4. Chimelski, Maj Steve, HQ AFMC/XRX, Wright-Patterson AFB OH. Suggested Thesis Topic. 26 Jul 94.

5. Cooper, Donald R. and C. William Emory. Business Research Methods. Chicago: Irwin, 1995.

6. Elmasri, Ramez and Shamkant B. Navathe. Fundamentals of Database Systems. Redwood City CA: Benjamin/Cummings Publishing Company, Inc., 1994.

7. Frontier Engineering, Inc. Intermediate Microsoft Access 2.0. Dayton OH: 1994

8. Frontier Engineering, Inc. Introduction to Microsoft Access 2.0. Dayton OH: 1994

9. Hollocks, B. W. "The Impact of Simulation in Manufacturing Decision Making," Control Engineering Practice, 3: 105-112 (1995).

10. Laudon, Kenneth C. and Jane Price Laudon. Management Information Systems, A Contemporary Perspective. New York: Macmillan Publishing Company, 1988.

11. Law, Averill M. and W. David Kelton. Simulation Modeling and Analysis. New York: McGraw-Hill, Inc., 1982.

12. McKinney, Bernie. 412 Test Wing, Edwards AFB CA. Personal interview. 5 Jul 95.

13. Microsoft Corporation. Building Applications. Microsoft Access. 1994.

14. Microsoft Corporation. User's Guide. Microsoft Access. 1994.

15. Oren, Tuncer I. "Artificial Intelligence in Simulation," Annals of Operations Research, 53: 287-319 (1994).

16. Perkinson, Richard C. Data Analysis: The Key to Data Base Design. Wellesley MA: QED Information Sciences, Inc., 1984.

17. Piplani, Col Lalit K. Lt Col Joseph G. Mercer, and Lt Col Richard O. Roop, Systems Acquisition Manager's Guide for the Use of Models and Simulation. Fort Belvoir VA: Defense Systems Management College Press, September 1994.

18. Preece, Jenny and H. Dieter Rombach. "A Taxonomy for Combining Software Engineering and Human-Computer Interaction Measurement Approaches: Towards a Common Framework," International Journal of Human-Computer Studies, 41: 553-583 (1994).

19. Ragsdale, 1Lt Tim and Capt William Greer. SMC/XRES, Los Angeles AFB CA. Personal Interview. 20 - 24 Mar 1995.

20. Ricciardi, Sal. "Introduction to Logical Database Design," PC Magazine, 13: 267-269 (11 January 1994).

21. Scribner, Capt Kenn, Joe Nalepka, and Brian Stadler. WL/FIGD, Wright-Patterson AFB OH. Personal Interview. 28-31 Jul 1995.

22. Secretary of the Air Force (SAF/AQ). Product Management Modeling and Simulation (Draft). AFI 16-1003. Washington DC: SAF, 8 March 1995.

23. Siegel, Charles. Teach Yourself Access 2.0 for Windows. New York: Henry Holt and Company, Inc., 1994.

24. Simard, Richard J. Rome Air Development Center Laboratory, Griffiss AFB NY. Personal interview. 20 Jul 95.

25. Teorey, Toby J. and James P. Fry. Design of Database Structures. Englewood Cliffs NJ: Prentice-Hall, Inc., 1982.

26. Townsend, James J. Introduction to Databases. Carmel IN: Que Corporation, 1992

27. Under Secretary of Defense (Acquisition and Technology). Modeling and Simulation (M&S) Master Plan (Draft). DoD 5000.59-Paa. Washington DC: GPO, January 1995.

Vita

Captain Timothy J. Wagner is from Oil City, Pennsylvania. He enlisted in the Air Force in 1977 and, after his first three duty assignments, was selected to attend Penn State University under the auspices of the Airmen's Education and Commissioning Program (AECP). He graduated in December of 1987 with a Bachelor of Science degree in Industrial Engineering. He received his commission from Officer Training School on 13 April 1988. He spent three years working for HQ Air Force Management Engineering Agency (AFMEA) in San Antonio, Texas and its field unit the Air Force Security Police Management Engineering Team (AFSPMET) in Albuquerque, New Mexico. His next duty assignment was to Malstrom AFB in Great Falls, Montana as a missile launch officer. Upon notification of his acceptance to the Air Force Institute of Technology (AFIT), Captain Wagner was working as a Flight Lead and Squadron Scheduler for the 10th Missile Squadron. While at Malstrom AFB, he earned a Masters of Education degree in Guidance and Counseling. In April 1994, he entered the AFIT School of Logistics and Acquisition Management at Wright-Patterson AFB, Ohio. He graduated in September 1995 with a Masters degree in Cost Analysis. He was subsequently assigned to the Space and Missile Center (SMC), Los Angeles, California.

Permanent Address: 908 Innis St
Oil City, PA 16301

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
September 1995

3. REPORT TYPE AND DATES COVERED
Master's Thesis

4. TITLE AND SUBTITLE
AIR FORCE MATERIEL COMMAND (AFMC) MODELING, SIMULATION, AND ANALYSIS (MS&A) INTERACTIVE DATABASE

5. FUNDING NUMBERS

6. AUTHOR(S)
Timothy J. Wagner, Captain, USAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology,
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GCA/LAS/95S-12

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
HQ AFMC/XRX
WPAFB OH 45433

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This study develops a high level, unifying taxonomy for Modeling, Simulation, and Analysis (MS&A) products for the Air Force Materiel Command (AFMC). AFMC is concerned that limited resources are being expended on duplicative MS&A efforts. No mechanism exists that would confirm or deny this concern, so it was suggested that a database could be developed to catalog and track AFMC's MS&A inventory. First, it was necessary to determine the information that a decision maker needs to select a suitable MS&A product. Potential traits and characteristics were identified through review of current regulatory guidance, interviews with MS&A users, and a study of the current literature. Using the collected information, a survey was developed and distributed to 40 members of the Modeling and Simulation Technical Planning Integrated Product Team (M&S TPIPT). Survey results provided the foundation for developing a limited prototype database. This prototype was tested to ascertain the retrieval performance of the cataloging system. The test results failed to confirm the retrieval capability, but the test participants believed that cataloging AFMC's MS&A inventory would have great benefit.

14. SUBJECT TERMS
Models, Simulation, Databases, Taxonomy

15. NUMBER OF PAGES
119

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std. Z39-18